

## **Theme Overview**

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NASA's Earth Science Theme advances knowledge of the integrated Earth system, the global atmosphere, oceans (including sea ice), land surfaces, ecosystems, and interactions between all elements, including the impacts of humans. Sustained, simultaneous observations of many quantities are needed to unravel the complexity of the global Earth system. Maintaining balance continues to be a hallmark of NASA's Earth Science Theme: Flight Programs develop satellite missions and provide observations; Research redeems the investment in flight by analyses to increase scientific understanding and identify the foci for future missions; Technology develops new measurement approaches; and Applied Sciences provides direct societal benefit by advancing the use of Earth science measurements and scientific understanding to undergird environmental policy decisions.

The President's Budget advances key elements of the program established in NASA's 2010 Climate Initiative. The budget enables launch of the first two Tier 1 decadal survey missions, Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat)-2, by CY 2016 and expands the Venture-class competitive program with annual solicitations for facility-class instruments and alternating biannual solicitations for small missions and airborne investigations. The budget supports continued development of options for the decadal survey's Tier-1 Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) Radar satellite. Two climate-focused Tier-2 decadal survey missions--Surface Water and Ocean Topography (SWOT) for insight into the movement and distribution of fresh surface water, and Active Sensing of Carbon dioxide Emissions over Nights, Days and Seasons (ASCENDS) for atmospheric column carbon dioxide (CO<sub>2</sub>) abundance--have been initiated for launch in 2019-2020. Recognizing the broad societal and policy impact of NASA's Earth observations, NASA will continue to develop the Orbiting Carbon Observatory (OCO)-2 for launch in 2013, begin building OCO-3 as a mission of opportunity, and initiate missions to continue climate time series. NASA will refurbish a Stratospheric Aerosols and Gas Experiment III (SAGE III) instrument for flight on the ISS as early as 2014, develop the Pre-Aerosols, Carbon and Ecosystems (PACE) mission for ocean color, and initiate a Gravity Recovery and Climate Experiment (GRACE) Follow-on gap-filler mission for launch in 2016 (in collaboration with the German space agency, DLR) to continue the measurements, including observations of changes in terrestrial water storage and ice mass, now made by the aging GRACE mission.

NASA Earth Science operates 13 satellite missions making calibrated global observations with high spatial and temporal resolution. Two missions (ICESat, QuikSCAT) recently ended their main scientific missions after extended lifetimes. The ICESat spacecraft was deorbited flawlessly, including a successful experiment to acquire GPS data during its descent. More than 11 years after launch, QuikSCAT is still being used as a transfer standard to enhance the utility of data from international scatterometers. NASA has seven missions in formulation and development, of which Glory, Aquarius, and the NPOESS Preparatory Project (NPP) are scheduled for launch in 2011.

NASA aircraft and surface instruments calibrate, complement, and expand the value of satellite measurements. NASA supports computing capability and capacity for Earth system modeling. NASA missions produce nearly 4 terabytes of data daily, and NASA maintains the world's largest scientific data and information system for processing, archiving, and distributing Earth system data to worldwide users. International collaborations including collaborative space missions, joint research efforts, and information/education programs such as Global Learning and Observations to Benefit the Environment (GLOBE) and SERVIR are essential for the Earth Science Theme.

**Mission Directorate:** Science  
**Theme:** Earth Science

**FY 2012 Budget Request**

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b><u>1,439.3</u></b>	<b>-</b>	<b><u>1,653.0</u></b>	<b><u>1,679.2</u></b>	<b><u>1,665.3</u></b>	<b><u>1,691.4</u></b>	<b><u>1,727.3</u></b>
Earth Science Research	375.8	-	409.6	419.0	427.3	436.7	444.6
Earth Systematic Missions	705.2	-	816.5	838.7	761.6	763.2	810.7
Earth System Science Pathfinder	128.4	-	187.8	180.6	229.5	238.4	214.3
Earth Science Multi-Mission Operations	149.0	-	159.9	158.8	159.4	162.9	166.6
Earth Science Technology	45.6	-	46.1	47.9	51.9	53.6	54.2
Applied Sciences	35.3	-	33.1	34.3	35.5	36.7	36.9

*Note: The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the program amounts shown above. The allocation to each program is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## **Plans for FY 2012**

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### **Earth Science Research**

SMD will issue Research Opportunities in Space and Earth Science 2011 (ROSES-11), a research announcement covering all of its planned solicitations, including Earth Science Research. The FY 2012 budget will fund research competitively selected in FY 2011 under this ROSES call. About 33 percent of the Earth Science Research budget is competed each year through ROSES, with successful investigations funded usually through three-year grants. Thus many of the research activities carried out in FY 2012 will be tasks initiated in FY 2010 and FY 2011 based on solicitations included in ROSES-09 and ROSES-10. Selections based on ROSES-09 and -10 solicitations are on-going and are addressing diverse Earth Science research areas, including biodiversity, ocean salinity, hurricane and precipitation science, remote sensing of water quality, atmospheric composition, and interdisciplinary science.

NASA will continue implementation of the airborne IceBridge campaign to acquire essential polar ice data during the gap between the ICESat and ICESat-2 missions. This activity, focusing on changes in Greenland and Arctic ice, will continue in FY 2012 and each year until ICESat-2's launch in 2016.

In addition, the Research Program develops and tests experimental techniques and algorithms that contribute to future satellite missions. The FY 2012 President's Budget enhances support for interdisciplinary science and NASA observational- and model-based contributions to national and international climate assessments, as well as provides increased key investments in scientific computing and space geodesy.

## **Plans for FY 2012**

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### **Earth Systematic Missions**

In FY 2012, the President's Budget accelerates or initiates Systematic Missions recommended by the National Academies' 2007 decadal survey. Implementation of SMAP and ICESat-2 missions will continue with launches in late CY 2014 and CY 2016, respectively. Phase A formulation activities will be completed for the DESDynI mission, with the NASA effort focusing on the radar satellite while seeking partner contributions for the Lidar element. The DESDynI launch date will be determined based on Phase A studies conducted in FY 2011. Pre-Phase A studies will continue for the remaining Tier-1 decadal survey mission, the Climate Absolute Radiance and Refractivity Observatory (CLARREO). In addition, in conjunction with the U.S. Global Change Research Program (USGCRP), NASA has identified two key climate-related Tier-2 decadal survey missions and will continue pre-formulation activities toward a CY 2019 launch.

The following other activities will be undertaken or accomplished in FY 2012:

- The Global Precipitation Measurement (GPM) project will complete its Systems Integration Review (SIR) and Key Decision Point (KDP)-D;
- The NPOESS (National Polar-orbiting Operational Satellite System) Preparatory Project (NPP) will complete all pre-launch activities, launch, and conduct the initial on-orbit check out and instrument calibration and validation;
- The Glory spacecraft will complete its on-orbit check out and deliver the first calibrated and validated Aerosol Polarimetry Sensor (APS) data products;
- The Landsat Data Continuity Mission (LDCM) will complete the Flight Operations Review (FOR);
- LDCM will complete the integration and testing of the observatory and the observatory Pre-Ship Review;
- Soil Moisture Active and Passive (SMAP) will complete the mission Critical Design Review (CDR);
- ICESat-2 will complete KDP-B and initiate the spacecraft contract;
- DESDynI will complete its Phase A formulation activities;
- The new Gravity Recovery and Climate Experiment (GRACE) Follow-on continuity mission will complete a pre-formulation phase and enter into Phase A formulation;
- The Stratospheric Aerosol and Gas Experiment (SAGE) III instrument will complete its International Space Station (ISS) accommodation assessment and initial instrument refurbishment;
- The Tier II missions Surface Water Ocean Topography (SWOT) and Active Sensing of CO<sub>2</sub> Emissions over Nights, Days, and Seasons (ASCENDS) will complete their pre-Phase A activities and enter into formulation with the completion of KDP-A for each; and
- The 13 operating missions will implement the direction from the Senior Review conducted in FY 2011.

## **Plans for FY 2012**

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### **Earth System Science Pathfinder**

The Earth System Science Pathfinder (ESSP) Program plans for FY 2012 include:

- The Aquarius/ Satellite de Aplicaciones Cientificas (SAC)-D mission will complete its on orbit checkout and begin sustained observations;
- The OCO-2 mission will see delivery of the spacecraft and the completion of the mission SIR, leading to a target launch readiness date of February 2013;
- Continuation of the Earth Venture-class (EV)-1 sustained airborne science campaigns;
- Selection of the winning proposals for EV-2, the first complete small mission Announcement of Opportunity (AO) (following release of the EV-2 AO in FY 2011);
- Release of the first EV-Instrument AO for a facility class Earth Science Instrument of Opportunity and selection of the winning proposal(s); and
- Continued on-orbit operation of GRACE, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO), and CloudSat as determined by the 2011 Senior Review.

### **Earth Science Multi-Mission Operations**

The Earth Science Multi-Mission Operations Program will continue to operate the Earth Observing System Data and Information System (EOSDIS), the Distributed Active Archive Centers (DAACs) and their accompanying functions, as well as Core System Science Data Processing Systems. The maintenance and operations of these systems are important to the collection of data from Earth Science satellites in orbit, as well as to the continuity of Earth science research efforts. NASA plans to continue support of the EOSDIS Evolution efforts to enable a service-oriented architecture between now and FY 2015, and to enable incorporation of the new, developing, and planned missions and Venture class aircraft investigations.

Five-year Making Earth Science Data Records for Use in Research Environments (MEaSUREs) Projects began work in FY 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. An Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation was released in ROSES-09, and ACCESS projects begun in FY 2010 will be completed in 2012. A new program, Earth System Data Records Uncertainty Analysis, has projects that are beginning in FY 2011. These Cooperative Agreements are proving valuable for keeping research and modeling communities actively involved with the EOSDIS architecture and informing core infrastructure evolution decisions.

## **Plans for FY 2012**

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### **Earth Science Technology**

The Earth Science Technology Program (ESTP) will plan and implement development of new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements and data system capabilities. A key goal of the program is to support the core Earth Science missions as defined by the decadal survey, along with other climate-monitoring missions that are part of the architecture plan. ESTP will identify technology needs based upon measurement priorities established by the science community, leading to systematically developed technology requirements and assessments of risk. The program may conduct studies to assess measurement options for meeting technology performance requirements. Ideas to address technology requirements will be solicited through an open, competitive process. The program provides rigorous management of the tasks selected for award such that costs and risks are minimized. There are three technology focus areas supported by ESTP: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives. The FY 2012 President's Budget supports expansion of currently planned activities.

For FY 2012, ongoing investigations will be managed in the Instrument Incubator, Advanced Information Systems Technology, and Advanced Component Technology areas. These investigations resulted from ROSES solicitations that occurred during FY 2010 and FY 2011. Each solicitation supported the expanded and accelerated mission set enabled by the President's Budget, including the Climate Initiative.

### **Applied Sciences**

In FY 2012, the Applied Sciences Program will continue or initiate projects across a range of application areas, including health and air quality, water resources, disasters, and ecological forecasting. These projects are competitively selected through NASA's ROSES solicitations. In FY 2012, the program will pursue increased joint projects with end-user organizations, representation in satellite mission teams, and continuation of capacity building efforts to build skills and capabilities for accessing and applying Earth observations data to benefit society. The FY 2012 President's Budget enables the program to initiate new solicitations, improve end-user involvement in early phase mission planning, support services provided by the NASA/USAID joint-funded SERVIR network, and improve the communication of results.

## Relevance

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### ***Relevance to national priorities, relevant fields, and customer needs:***

NASA's Earth Science Program uses unique capabilities in global Earth observations and models to discover scientific knowledge about the integrated Earth system. NASA provides the bulk of the global observations and research of USGCRP, and much of the observations and research that forms the basis for international scientific assessments of climate change. NASA activities contribute substantially to three Presidential initiatives (Integrated Global Earth Observations, the Ocean Policy Task Force, and the Climate Change Adaptation Task Force), three Congressional Initiatives (National Oceanographic Partnership Program, Global Change Research Act, and Clean Air Act Amendments), and two United Nations Assessments (Intergovernmental Panel on Climate Change and Ozone Depletion). NASA is the largest funding contributor to the 13-agency USGCRP and a participating agency in the National Climate Assessments. NASA is working to implement recommendations made in the National Academies' decadal survey report, "Earth Observations and Applications from Space: National Imperatives for the Next Decade and Beyond" (2007), which expresses the priorities of the U.S. science community.

NASA coordinates with the U.S. Geological Survey (USGS) on LDCM, a partnership that is evolving in keeping with the maturity of land cover remote sensing. Future Landsat missions will be funded through the USGS, with NASA serving as its acquisition agent. Similarly, NASA is a long-term partner with the National Oceanic and Atmospheric Administration (NOAA) for building and launching U.S. civilian weather satellites under reimbursable agreements. With the President's FY 2011 budget request, the Administration announced a restructuring of the NPOESS program. NASA and NOAA will take responsibility for the satellites operating in the afternoon orbit. The new Joint Polar Satellite System (JPSS) will be funded by NOAA, with NASA serving as the acquisition agency. NASA is also collaborating with NOAA to acquire key climate measurements and transition them into the operational satellite system.

### ***Relevance to the NASA Mission and Strategic Goals:***

Earth Science research supports NASA's Strategic Goal 2, to "Expand scientific understanding of the Earth and the universe in which we live."

***Relevance to education and public benefits:***

NASA consistently supports and develops programs to improve public understanding of the complexity of the global integrated Earth system and educate and train the next generation of scientists and engineers to ensure a robust workforce for this national endeavor. NASA is the largest contributor to GLOBE, an international program that involves students in making hands-on observations of Earth's environment and sharing them as part of an international community of learners. Infusing NASA Earth observations and scientific results, NASA supports innovative projects in formal and informal education to stimulate science, technology, engineering, and mathematics (STEM) learning in schools and engage the public. The DEVELOP Program (not an acronym) is a national high school and university student-led, student-run internship activity. NASA's Earth System Science Fellowship Program trains graduate students, while the New Investigator Program targets early-career scientists and engineers. NASA Earth science discoveries are reported almost daily through the world's media to engage students and the public to appreciate the complexity of the Earth system and global environment.

Guided primarily by the 2007 National Academies' decadal survey for Earth science, NASA is executing an ambitious plan to answer questions regarding why and how the environment is changing, define the impacts of environmental change on humans, and identify how humans can mitigate the impact of environmental hazards. Through its work with other Federal agencies to improve their operational services, NASA Earth science advances capabilities in such areas as weather and air quality forecasting, climate prediction, and natural hazard and land use assessment.



## Performance

### Performance Commitments:

Measure #	Description	Contributing Program (s)
<b>Strategic Goal 2</b>	<b>Expand scientific understanding of the Earth and the universe in which we live.</b>	
<b>Outcome 2.1</b>	<b>Advance Earth system science to meet the challenges of climate and environmental change.</b>	
<b>Objective 2.1.1</b>	<b>Improve understanding of and improve the predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.</b>	
<b>Performance Goal 2.1.1.1</b>	<b><i>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</i></b>	
APG 2.1.1.1: ES-12-1	Demonstrate planned progress in understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
<b>Performance Goal 2.1.1.2</b>	<b><i>By 2015, launch at least two missions in support of this objective.</i></b>	
APG 2.1.1.2: ES-12-2	Complete the Orbiting Carbon Observatory-2 (OCO-2) Systems Integration Review.	Earth System Science Pathfinder
APG 2.1.1.2: ES-12-3	Complete the Earth Venture 1 (EV-1) Investigation Readiness Reviews (IRR) and begin initial field campaigns.	Earth System Science Pathfinder
<b>Objective 2.1.2</b>	<b>Enable improved predictive capability for weather and extreme weather events.</b>	
<b>Performance Goal 2.1.2.1</b>	<b><i>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</i></b>	
APG 2.1.2.1: ES-12-4	Demonstrate planned progress in enabling improved predictive capability for weather and extreme weather events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
<b>Performance Goal 2.1.2.2</b>	<b><i>By 2015, launch at least two missions in support of this objective.</i></b>	
APG 2.1.2.2 ES-12-5	Complete the Global Precipitation Mission (GPM) Pre-Environmental Review.	Earth Systematic Missions
APG 2.1.2.2: ES-12-3	Complete the EV-1 Investigation Readiness Reviews (IRR) and begin initial field campaigns.	Earth System Science Pathfinder

## Performance

### Performance Commitments:

Measure #	Description	Contributing Program (s)
<b>Objective 2.1.3</b>	<b>Quantify, understand, and predict changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity.</b>	
<b>Performance Goal 2.1.3.1</b>	<b><i>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</i></b>	
APG 2.1.3.1: ES-12-6	Demonstrate planned progress in quantifying, understanding, and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
<b>Performance Goal 2.1.3.2</b>	<b><i>By 2015, launch at least two missions in support of this objective.</i></b>	
APG 2.1.3.2 ES-12-7	Complete the Landsat Data Continuity Mission (LDCM) Systems Integration Review.	Earth Systematic Missions
APG 2.1.3.2: ES-12-2	Complete the Orbiting Carbon Observatory-2 (OCO-2) Systems Integration Review.	Earth System Science Pathfinder
APG 2.1.3.2: ES-12-3	Complete the Earth Venture 1 (EV-1) Investigation Readiness Reviews (IRR) and begin initial field campaigns.	Earth System Science Pathfinder
<b>Objective 2.1.4</b>	<b>Quantify the key reservoirs and fluxes in the global water cycle and assess water cycle change and water quality.</b>	
<b>Performance Goal 2.1.4.1</b>	<b><i>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</i></b>	
APG 2.1.4.1: ES-12-8	Demonstrate planned progress in quantifying the key reservoirs and fluxes in the global water cycle and assessing water cycle change and water quality. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
<b>Performance Goal 2.1.4.2</b>	<b><i>By 2015, launch at least two missions in support of this objective.</i></b>	
APG 2.1.4.2: ES-12-5	Complete the Global Precipitation Mission (GPM) Pre-Environmental Review.	Earth Systematic Missions
APG 2.1.4.2: ES-12-9	Successfully complete the Soil Moisture Active-Passive (SMAP) Critical Design Review.	Earth Systematic Missions
<b>Objective 2.1.5</b>	<b>Improve understanding of the roles of the ocean, atmosphere, land and ice in the climate system and improve predictive capability for its future evolution.</b>	
<b>Performance Goal 2.1.5.1</b>	<b><i>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</i></b>	
APG 2.1.5.1: ES-12-10	Demonstrate planned progress in understanding the roles of ocean, atmosphere, land, and ice in the climate system and improving predictive capability for future evolution. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
APG 2.1.5.1: ES-12-11	Achieve mission success criteria for the Ocean Surface Topography Mission (OSTM).	Earth Systematic Missions

## Performance

### Performance Commitments:

Measure #	Description	Contributing Program (s)
<b>Performance Goal 2.1.5.2</b>	<b>HPPG: Study Earth from space to understand climate change, weather, and human impact on our planet by launching at least two missions by 2015.</b>	
APG 2.1.5.2: ES-12-12	Launch the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP).	Earth Systematic Missions
<b>Performance Goal 2.1.5.3</b>	<b>By 2015, launch at least three missions in support of this objective.</b>	
APG 2.1.5.3: ES-12-13	Complete the ICESat-2 Preliminary Design Review.	Earth System Science Pathfinder
APG 2.1.5.3: ES-12-2	Complete the Orbiting Carbon Observatory-2 (OCO-2) Systems Integration Review.	Earth System Science Pathfinder
<b>Objective 2.1.6</b>	<b>Characterize the dynamics of Earth's surface and interior and form the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events.</b>	
<b>Performance Goal 2.1.6.1</b>	<b>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</b>	
APG 2.1.6.1: ES-12-14	Demonstrate planned progress in characterizing the dynamics of Earth's surface and interior and forming the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.	Multiple Programs
<b>Performance Goal 2.1.6.2</b>	<b>By 2015, launch at least one mission in support of this objective.</b>	
APG 2.1.6.2: ES-12-7	Complete the Landsat Data Continuity Mission (LDCM) Systems Integration Review.	Earth Systematic Missions
<b>Objective 2.1.7</b>	<b>Enable the broad use of Earth system science observations and results in decision-making activities for societal benefits.</b>	
<b>Performance Goal 2.1.7.1</b>	<b>Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base.</b>	
APG 2.1.7.1: ES-12-15	Advance at least 25 percent of decision-support projects at least one Applications Readiness Level.	Applied Sciences
APG 2.1.7.1: ES-12-16	Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users.	Earth Science Research
APG 2.1.7.1: ES-12-17	Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index.	Earth Science Research

***Uniform and Efficiency Measures:***

Measure #	Description
<b>Earth Science Theme</b>	
APG EFF 2.1.7.1: ES-12-16	Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users.
APG EFF 2.1.7.1: ES-12-17	Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index.
APG EFF: ES-12-20	Complete all development projects within 110 percent of the cost and schedule baseline.
APG EFF: ES-12-21	Deliver at least 90 percent of scheduled operating hours for all operations and research facilities.
APG EFF: ES-12-22	Peer-review and competitively award at least 90 percent, by budget, of research projects.
APG EFF: ES-12-23	Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days.

***Performance Achievement Highlights:***

Using nearly a decade of NASA satellite ocean measurements from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS), a study appearing in the April issue of *Ecology* showed that the classic North Atlantic bloom, an explosive ocean plant growth, does not begin in the spring, as thought for 100 years, but rather in the middle of winter, and is the result of ocean mixing interfering with predator-prey interactions of marine ecosystems. The massive high-latitude phytoplankton blooms supporting fisheries and ocean uptake of CO<sub>2</sub> have been discovered to begin in midwinter when low light, low temperatures, and severe storms make growing conditions poorest. Stormy winter conditions initiate biological productivity and may be dampened by climate change, thus reducing ocean CO<sub>2</sub> uptake and impacting fisheries. This finding overturns a century-old paradigm on blooms, and suggests that future climate warming could be devastating to these economically and environmentally important ocean regions.

Researchers have analyzed time series data from Terra's Moderate Resolution Imaging Spectroradiometer (MODIS) in combination with climate data and reported a slight ten-year decline in global terrestrial plant productivity of one percent from 2000 through 2009 (a six percent increase was reported for 1982 through 1999 in 2003). The analysis shows that since 2000, high-latitude northern hemisphere forests have continued to benefit from warmer temperatures and a longer growing season. However, warming-associated drought limited growth in the southern hemisphere and offset the increases in the northern hemisphere, resulting in a net global loss of productivity. A continued decline in global productivity will weaken the terrestrial carbon sink and intensify the pressures on ecosystems for food, fiber, and biofuel production. Continued monitoring will be essential to explain whether this new trend is an example of decadal variability or a turning point to overall declines in productivity.

During an airborne campaign in spring 2010, nicknamed GloPac, NASA's Global Hawk unmanned aerial system (UAS) carried 11 instruments to sample the chemical composition of air in Earth's two lowest atmospheric layers (the stratosphere and troposphere), profile the dynamics and meteorology of both, and observe the distribution of clouds and aerosol particles. The instruments are operated by scientists and technicians from seven science institutions and are funded by NASA and the NOAA. The GloPac mission showed that the Global Hawk aircraft is a revolutionary tool for Earth science research, proven to be a science platform that can fly to altitudes of 65,000 feet for long-duration flights approaching 30 hours. This successful experiment was followed by another equally successful mission called the Genesis and Rapid Intensification Processes (GRIP) experiment, designed to bring new insight into how hurricanes form and intensify. NASA enjoyed a historic day for its hurricane research on September 2, 2010, as flew the Global Hawk over hurricane Earl, marking the first time the unmanned drone flew over a fully formed hurricane. The Global Hawk was piloted and based from NASA's Dryden Flight Research Center (DFRC), in Palmdale, California, while flying for up to 20 hours in the vicinity of hurricanes in the Atlantic and Gulf of Mexico. The GRIP campaign was the first multi-platform field campaign using a UAS; other platforms included the NASA WB-57F and DC-8, as well as aircraft from other agencies flown in coordination with NASA's. In order to determine how a tropical cyclone will behave, the instruments gathered data to analyze many factors, including cloud droplet and aerosol concentrations, air temperature, wind speed and direction in storms and on the ocean's surface, air pressure, humidity, lightning, aerosols, and water vapor. The data both complement and validate the observations from NASA's satellites.

**Mission Directorate:** Science  
**Theme:** Earth Science

***Independent Reviews:***

<b>Review Type</b>	<b>Performer</b>	<b>Last Review</b>	<b>Purpose/Outcome</b>	<b>Next Review</b>
Relevance	NASA Advisory Council (NAC)	09/2010	NASA Advisory Council (NAC) Science Committee - Review science strategy and implementation strategy for the Earth Science programs.	2011
Relevance	National Academies	N/A	National Academies - per Authorization Act of 2005, perform a quinquennial review of scientific progress against decadal survey recommendations.	2011
Relevance	National Academies	01/2007	National Academies - Decadal survey of effectiveness and quality of the Earth Science programs. First time a decadal survey was developed for Earth science. For more information: <a href="http://www.nap.edu/catalog.php?record_id=11820">http://www.nap.edu/catalog.php?record_id=11820</a> .	2016

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Research

## FY 2012 Budget Request

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Earth Science Research and Analysis	275.7	-	304.0	311.1	316.6	324.2	330.9
Computing and Management	100.1	-	105.7	107.8	110.8	112.5	113.7

*Note:*

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## Program Overview

The Earth Science Research Program aims to advance understanding of the Earth system, its components and their interactions, its changes, and the consequences of these changes for life. Earth system processes occur on a continuum of spatial and temporal scales and affect weather, climate, air quality, water resources, biodiversity, and other environmental aspects. The program pioneers the use of remote sensing data, primarily space-based, in new and innovative ways, and leverages NASA's unique capabilities in global Earth observation.

Earth Science Research sponsors basic disciplinary and interdisciplinary research, Earth system modeling efforts, the Airborne Science project (which provides access to aircraft and unmanned aircraft systems), and supercomputing efforts supporting a variety of programs, as well as education and outreach.

For more information, please see <http://nasascience.nasa.gov/earth-science/>.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Research

## Plans For FY 2012

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The Research and Analysis (R&A) project constitutes the core of the program and accounts for about half of its total budget. It is mostly competed via the annual SMD ROSES solicitations. ROSES-11, released in February 2011, will result in grants funded with FY 2012 funding and two subsequent years. The project will also continue funding research tasks solicited in ROSES-10 and ROSES-09 as they progress into their second and third years, respectively. The research portfolio includes the Interdisciplinary Science project, also competed in ROSES, with a focus on research in interdisciplinary areas such as sea level change, water and energy cycle impacts of biomass burning, and integrated Earth system responses to extreme disturbances. Other competitive grant projects are the carbon cycle science team and the Earth science education and outreach activity. The remaining activities include directed funding to NASA Centers for Space Geodesy (for development and operation of the geodetic networks), high-end computing and scientific computing, and global modeling and data assimilation.

The FY 2012 President's Budget enhances support for interdisciplinary science, for observational and model-based contributions to national and international climate assessments, for work towards a Carbon Monitoring System (CMS), specifically the development of two pilot products, and for a scoping study and increased investment in scientific computing and space geodesy. The two pilot products from CMS are a terrestrial biomass pilot product and an integrated emission/uptake (flux) pilot product. The terrestrial biomass pilot product utilizes satellite and in situ data, produces national quantitative estimates (and uncertainties) of above-ground terrestrial vegetation biomass and assesses the ability of these results to meet the nation's need for monitoring carbon storage and sequestration. NASA will demonstrate how well biomass can be quantified with high quality remotely sensed data (e.g., airborne lidar) taken at fine spatial resolution for selected sites representative of U.S. forest types and conditions. Sites with intensive inventory measurements will be selected so that comparisons with county, state, and national carbon and biomass inventory products can be made. The accuracy of and uncertainties within the national biomass map product will be evaluated using these high-resolution products for validation. The integrated emission/uptake (flux) pilot product combines satellite data with modeled atmospheric transport initiated by observationally constrained terrestrial and oceanic models to tie the atmospheric observations to surface exchange processes and estimates the atmosphere-biosphere CO<sub>2</sub> exchange processes.



<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Research

## **Project Descriptions and Explanation of Changes**

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### ***Earth Science Research and Analysis***

The Earth Science Research Program area consists of multiple projects and science teams that support the diverse R&A goals.

**Research and Analysis:** The Earth Science project is the core of the research program and funds the analysis and interpretation of data from NASA's satellites, as well as a full range of underlying scientific activity needed to establish a rigorous base for the satellite data and their use in computational models (for both assimilation and forecasting). The complexity of the Earth system, in which spatial and temporal variability exists on a range of scales, requires an organized approach for addressing complex, interdisciplinary problems, taking care to recognize the objective of integrating science across the programmatic elements towards a comprehensive understanding of the Earth system. The resulting structure comprises six interdisciplinary and interrelated science focus areas: climate variability and change; atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; weather; and Earth surface and interior. Additionally, the R&A project addresses the Earth system and the interactions between its components, characterizing them on a broad range of spatial and temporal scales to understand the naturally occurring and human-induced processes that drive the overall system.

**Airborne Science:** Airborne Science funds NASA's Earth science manned and unmanned aircraft. The project supports the operation of a range of NASA-owned and leased aircraft, including the ER-2, DC-8, WB-57, P-3, Twin Otter, B-200, and the Global Hawk and other UAS. These assets are deployed in campaigns conducted around the world to investigate extreme weather events (e.g., hurricanes), observe Earth system processes, obtain data for Earth science modeling activities, and calibrate instruments flying aboard Earth science spacecraft. NASA will continue IceBridge, an Airborne Science campaign, conducted to bridge the gap between ICESat and ICESat-2 observations. This activity, focusing on changes in Greenland, Arctic, and Antarctic ice, will continue each year until ICESat-2's launch in 2016.

**Interdisciplinary Science:** Interdisciplinary Science supports science investigations and calibration and validation activities that ensure the utility of spaceborne measurements. In addition, it supports focused field work (e.g., airborne campaigns) and specific facility instruments that are heavily relied upon in field work.

**Carbon Cycle Science:** The Carbon Cycle Science project funds research on the distribution and cycling of carbon among the Earth's active land, ocean, and atmospheric reservoirs.

**Global Modeling and Assimilation Office:** The Global Modeling and Assimilation Office, located at Goddard Space Flight Center (GSFC), creates global climate and Earth system component models using data from Earth science satellites and aircraft. These products can then be used by investigators worldwide to further their research.

**Ozone Trends Science:** The Ozone Trends Science project has the overall goal of producing a consistent, calibrated ozone time series that can be used for trend analyses and other studies.

<b>Mission Directorate:</b>	Science
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### ***Earth Science Research and Analysis (continued)***

Education and Outreach Activity: The Education and Outreach Activity supports NASA's educational goals and communicate the results from Earth science missions and research. It also continues the worldwide implementation and U.S. coordination of the GLOBE Program.

Fellowships and New Investigators: The Fellowships and New Investigators project supports graduate and early-career research, respectively, that is relevant of Earth system research and applied science.

Space Geodesy: The Space Geodesy project provides global geodetic positioning and supports the establishment of needed geodetic reference frames in support of climate change and geohazards research and applications and their associated missions. The FY 2012 President's Budget will support the construction of the prototype for the next generation ground station for this network, whose development has been underway for several years.

### ***Computing and Management***

The Computing and Management area consists of three projects:

High-End Computing Capability - The High-End Computing Capability (HECC) project at Ames Research Center is focused around the Columbia and Pleiades supercomputer systems and the associated network connectivity, data storage, data analysis, visualization, and application software support. SMD currently funds and manages HECC resources, which serve the supercomputing needs of all NASA Mission Directorates as well as principal investigators at universities. SMD funding supports the operation, maintenance, and upgrade of NASA's supercomputing capability, while the Strategic Capabilities Assets Program exercises oversight and insight functions. In 2010, approximately 29,000 processors were added to the Pleiades supercomputer system. This system, with a total of about 82,000 processors, supports NASA's aeronautics, exploration, space operation, and science missions.

Scientific Computing - Scientific Computing funds NASA's Earth Science "Discover" computing system, software engineering, and user interface projects at GSFC, including assessment modeling carried out at the Goddard Institute for Space Studies. Scientific Computing supports Earth science modeling activities based on data collected by Earth science spacecraft. An additional 14,400 processors were added to the Discover cluster to accommodate increasing requirements in modeling and data analysis. The FY 2012 President's Budget provides increased support for hardware procurement and development of software systems designed to facilitate use of NASA computational hardware.

Directorate Support - The Directorate Support project contributes to the SMD institutional budget. It funds Directorate cross-cutting activities (i.e., National Academies, NASA Peer Review, printing and graphics, IT budget, NASA Postdoctoral program, working group support, independent assessment studies, and other Directorate administrative tasks).

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Research

### Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Issue competed, peer-reviewed research awards.	Research and Analysis; Airborne Science (flight opportunities)	
Maximize resource utilization (i.e., computing cycles) in supercomputer projects.	Scientific Computing; HECC	
Competitively selected airborne mission teams.	Continue operation ICEBridge	
Competitively selected shipborne mission team.	ICEScape (deployment #2)	
Competitively selected airborne mission teams.	Mid-latitude Airborne Cirrus Properties Experiment (MACPEX)	
Support National Climate Assessments	Support data products, investigators and workshops	
Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users.	Earth Science Research	
Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index.	Earth Science Research	

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Research

## Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Beg	End
R&A, IDS Science, Carbon Cycle Science, Ozone Trends, Global Modeling and Assimilation Office, Space Geodesy, Education and Outreach, Fellowships and New Investigators (all ongoing research efforts)																	Tech Form Dev Ops Res	Jan-90	Dec-23
Airborne Science																	Tech Form Dev Ops Res	Jan-90	Dec-23
Scientific Computing																	Tech Form Dev Ops Res	Jan-95	Dec-23
HECC																	Tech Form Dev Ops Res	Jan-05 Sep-05	Aug-05 Dec-23
<div> <div></div> Tech &amp; Adv Concepts (Tech)           <div></div> Formulation (Form)           <div></div> Development (Dev)           <div></div> Operations (Ops)           <div></div> Research (Res)           <div></div> Represents a period of no activity for the Project         </div>																			

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
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## Program Management

The Earth Science Theme manages the research program. GSFC implements scientific computing and the Ames Research Center (ARC) implements HECC.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
R&A	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	USGCRP participating agencies and Subcommittee on Ocean Science and Technology (SOST) participating agencies
Interdisciplinary Science	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	USGCRP participating agencies and SOST participating agencies
Carbon Cycle Science Team	Earth Science Theme, Science Mission Directorate	GSFC, Jet Propulsion Laboratory (JPL), ARC	USGCRP participating agencies and SOST participating agencies
Ozone Trends Science	Earth Science Theme, Science Mission Directorate	GSFC and Langley Research Center (LaRC)	USGCRP participating agencies and SOST participating agencies
Airborne Science	Earth Science Theme, Science Mission Directorate	GSFC/Wallops Flight Facility, DFRG, and ARC are the primary Centers involved in this project.	The Federal Aviation Administration, the Department of Defense, the Department of Energy, the National Science Foundation, and NOAA (Department of Commerce)
High-End Computing Capability	Earth Science Theme, Science Mission Directorate	NASA Advanced Supercomputing, ARC	Department of Energy and the Department of Defense
Scientific Computing	Earth Science Theme, Science Mission Directorate	NASA Center for Computational Sciences, GSFC	Department of Energy and the Department of Defense
Global Modeling and Assimilation Office (formerly Data Assimilation Office)	Earth Science Theme, Science Mission Directorate	GSFC	None
Space Geodesy	Earth Science Theme, Science Mission Directorate	GSFC, JPL	None
Earth Science Education and Outreach Activity	Science Mission Directorate	N/A (various non-NASA organizations)	National Science Foundation's Component of the Global Learning and Observations to Benefit the Environment (GLOBE)
Fellowships and New Investigators	Science Mission Directorate	N/A (various non-NASA organizations)	None

## Acquisition Strategy

The Earth Science Research Program is based on full and open competition. Proposals in response to NASA ROSES and other related announcements are peer reviewed and selected based on defined criteria.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Research

### Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC Earth Science Subcommittee (ESS)	2011	The NASA Advisory Council ESS reviews progress towards Earth Science objectives in the NASA Strategic Plan annually. During its 2010 meeting, the ESS reviewed and rated the ESD science metrics based on submitted accomplishments and peer-reviewed publications for FY 2010 in support of reporting requirements of the Government Performance and Results Act of 1993. All six science focus areas were rated "green" as documented in the FY 2010 Performance and Accountability Report.	2012

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b><u>705.2</u></b>	<b>-</b>	<b><u>816.5</u></b>	<b><u>838.7</u></b>	<b><u>761.6</u></b>	<b><u>763.2</u></b>	<b><u>810.7</u></b>
Global Precipitation Measurement (GPM)	155.0	-	83.8	68.7	41.4	27.2	20.1
Glory Mission	31.8	-	5.3	3.8	6.1	5.9	6.0
Landsat Data Continuity Mission (LDCM)	106.0	-	152.0	64.1	1.5	1.5	1.6
NPOESS Preparatory Project (NPP)	82.1	-	13.6	6.4	6.3	6.0	5.5
Ice, Cloud, and land Elevation Satellite (ICESat-II)	38.9	-	102.1	159.4	128.8	83.1	28.6
Soil Moisture Active and Passive (SMAP)	70.0	-	135.2	172.3	31.1	29.6	14.5
Other Missions and Data Analysis	221.5	-	324.6	364.0	546.4	609.9	734.5

*Note: The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

## Program Overview

The Earth Systematic Missions Program (ESMP) is responsible for developing facility (non-Principal Investigator (PI)-led) Earth observing research satellite missions, supporting and overseeing the operation of NASA facility research missions once on orbit, and producing standard mission products in support of NASA and national research, applications, and policy communities. In contrast with the PI-led missions in the Earth System Science Pathfinder (ESSP) Program, which are generally smaller and have highly focused scientific objectives, Earth Systematic Missions are designed to provide measurements and support for a wide a range of NASA science foci. Eight of the 13 presently on-orbit research missions for which NASA had development responsibility are operated under ESMP oversight (the U.S. Geological Survey operates Landsat-7, operational responsibility for OSTM/Jason-2 was transferred to NOAA as planned during FY 2009, and the Earth System Science Pathfinder (ESSP) program manages GRACE, CloudSat, and CALIPSO). Four of the five foundational missions presently in development are in the Earth Systematic Mission program (Glory, NPP, LDCM, and GPM). The National Academies' Earth science and applications decadal survey identifies 15 additional systematic NASA research missions that will be developed in the ESMP. Of these decadal survey missions, the President's FY 2012 budget provides funds for developing the first two Tier-1 systematic missions, SMAP and ICESat-2, for launch in 2014 and 2016, respectively. A third Tier I mission, DESDynI, will complete its pre-formulation pre-Phase A analysis of developmental option in FY 2012, during this time NASA will determine the most effective implementation approach for the combined Radar + Lidar mission. NASA will continue pre-phase A studies for the remaining Tier I mission, CLARREO. Additionally, the President's Budget allows expansion of the ESMP mission portfolio to include the development of the SAGE-III instrument for observing from the ISS (flight-ready in 2014), the development and launch of a GRACE-FO (follow-on) gapfiller mission in collaboration with DLR (2016 launch), the development and launch by FY 2020 of the PACE ocean color and aerosol mission, and advancement of two Tier-II Decadal Survey missions, SWOT and ASCENDS, selected for acceleration by NASA in consultation with USGCRP.

Interagency and international partnerships play key roles in the ESMP. Seven of the on-orbit missions provide data products in near-real time for use by U.S. and international meteorological agencies and disaster responders. Five of the on-orbit missions involved significant international or interagency collaboration in development, and the five-satellite A-Train formation-flying constellation (Aqua, CloudSat, CALIPSO, Aura, Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL)) consists of both NASA and international missions. Two of the four ESMP foundational missions presently in development involve interagency collaboration (NPP, LDCM), while GPM is a joint development between NASA and the Japanese Aerospace Exploration Agency (JAXA). Finally, the upcoming climate missions GRACE FO and Pre-Aerosol, Clouds, and ocean Ecosystem (PACE), and SWOT, a Tier II decadal survey mission, include significant international collaboration, as well. Partnering opportunities for DESDynI will be examined.

For more information, see <http://science.hq.nasa.gov/missions/earth.html>.



<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

## Plans For FY 2012

The President's Budget enables a wide range of ESMP activities during FY 2012. The Glory mission will be conducting its initial on-orbit checkout and validation in FY 2012, including the integration of the satellite into the A-Train constellation and the first evaluation of merged constellation data products and observations with Glory. The NPP mission will launch at the start of FY 2012 (October 2011) and will complete its initial on-orbit check out and calibration and validation activities. The Tier-1 decadal survey missions will pursue pre-formulation, formulation and implementation activities and milestone reviews targeting launches in November 2014 for SMAP and 2016 for ICESat-2. The launch plans for the DESDynI mission will be informed by the critical Phase A trade studies focused on implementation options and partnership possibilities. Increases in ESMP activities will be consistent with the focused expansion of the mission portfolio enabled by the budget, including initiation of the GRACE follow-on (GRACE FO) mission (2016 launch target), the PACE ocean color mission (FY 2020 target), and refurbishment activities to allow the SAGE-III instrument to be ready for flight on the ISS by CY 2014). The ASCENDS and SWOT Tier II decadal survey and selected continuity missions identified by NASA and the U.S. Global Change Research program for accelerated launches in the CY 2017-2020 time frame will also be entering into formulation in FY 2012.

The following specific activities will be undertaken or accomplished in FY 2012:

- Glory will complete its checkout and scientific validations, and begin routine data acquisition;
- GPM will complete its PER, SIR, and KDP-D and begin observatory level environmental testing;
- NPP is scheduled to launch October 2011 and will complete its initial on-orbit validation;
- LDCM will complete its spacecraft integration and test, and the Thermal Infrared Sensor (TIRS) and Operational Land Imager (OLI) instruments will be delivered to the spacecraft and KDP-D will be held;
- LDCM will conduct the majority of the Observatory level environmental testing and the FOR;
- SMAP will complete CDR;
- ICESat-2 will complete its mission Preliminary Design Review (PDR) and complete its confirmation review;
- DESDynI will complete its pre-Phase A activities;
- The GRACE FO mission will complete its Phase A formulation period and KDP-B;
- The SAGE III instrument will complete ISS accommodation assessment and will begin refurbishment;
- The PACE mission will complete pre-formulation activities and enter into Phase A;
- The decadal survey Tier-II SWOT mission will complete its pre-formulation activities and enter into Phase A early in FY2012;
- The decadal survey Tier II ASCENDS mission will complete its pre-formulation activities and enter into Phase A at the end of FY 2012; and
- The operating missions will continue with operations as directed following the FY 2011 bi-annual Senior Review.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

## **Project Descriptions and Explanation of Changes**

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### ***Global Precipitation Measurement (GPM) Mission***

Extending precipitation measurements beyond the current TRMM, the foundational mission GPM will provide detailed, frequent measurements of precipitation including rain rates and droplet size distributions. A joint mission between NASA and JAXA, GPM's two instruments will make valuable direct precipitation measurements and allow precise characterization of many other on-orbit NASA and partner instruments, enabling first-ever, accurate, near-global precipitation maps to be produced. GPM data will contribute to improved operational meteorological predictions, as well as to advances in the NASA science focus areas of climate variability and change, water and energy cycles, and weather. Additional GPM information is available under the Project in Development section of this document.

### ***Glory Mission***

Glory will provide unique measurements of the global distributions and scattering properties of natural and anthropogenic aerosols, as well as continue the nearly 30-year time series of total solar irradiance measurements. The NASA science focus areas advanced by Glory data include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability, and change; and water and energy cycles. Additional Glory information is available under the Project in Development section of this document.

### ***Landsat Data Continuity Mission (LDCM)***

LDCM, a collaboration between NASA and the U.S. Geological Survey, will provide moderate-resolution (15-120 meter, depending on spectral frequency) measurements of Earth's terrestrial and polar regions in the visible, near-infrared, and thermal infrared. LDCM will provide continuity with the 38-year long Landsat land imaging data set. In addition to widespread routine use for water use monitoring, land use planning and monitoring on regional to local scales, and support of disaster response and evaluations, LDCM measurements directly serve NASA research in Earth surface and interior, and carbon cycle, ecosystems, water cycle, and biogeochemistry focus areas. NASA's LDCM responsibilities include development of the LDCM visible/near-infrared and thermal infrared instruments, provision of the spacecraft and launch vehicle, and design/implementation of the USGS-funded Mission Operations Element. LDCM is being managed to a target December 2012 launch date, while reporting an external commitment date of June 2013. Additional LDCM information is available under the Project in Development section of this document.

### ***NPOESS Preparatory Project (NPP)***

NPP is a NASA research mission involving a collaboration between NASA, NOAA, and DoD, designed to extend selected scientific data sets initiated by the NASA Earth Observing System and to serve as risk reduction demonstrations for key instruments to be used in the Nation's future operational meteorological satellite systems. NPP is scheduled to launch in October 2011 and will ensure critical continuity in the nation's operational meteorological measurements from the afternoon orbit. The five instruments on NPP will provide visible and infrared multi-spectral global imagery, atmospheric temperature and moisture profiles, total ozone and stratospheric ozone profiles, and measurements of Earth's radiation balance. In addition to a wide range of applications studies, the NASA science focus areas served by NPP will include: atmospheric composition; climate variability and change; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; and weather. Additional NPP information is available under the Project in Development section of this document.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

### ***Ice, Cloud, and land Elevation Satellite-2 (ICESat-2)***

ICESat-2, a Tier-1 decadal survey mission that entered into formulation in FY 2010 and is being developed for a target launch in 2016, will continue the time series of precision ice topography measurements initiated by ICESat and extended in selected areas by the IceBridge campaigns. Time series of land ice topography in particular address a key open issue in climate modeling and prediction, the detailed mechanisms controlling ice sheet dynamics, and how these may change with changing climate. ICESat-2 measurements of land ice topography, sea ice extent and freeboard, and vegetation canopy height will address a range of NASA science investigations in the areas of cryospheric science; climate variability and change; and carbon cycle, ecosystems, and biogeochemistry. ICESat-2 is the planned follow-on mission to ICESat, measuring elements of ice-sheet mass balance and land surface topography to quantify the contribution to the current and recent sea level changes from changes in ice quantities and to establish linkages to climate change. Additional ICESat-2 information is available under the Project in Formulation section of this document.

### ***Soil Moisture Active and Passive (SMAP)***

The SMAP mission, a Tier-1 decadal survey mission, will provide new global measurements of soil moisture and land its freeze/thaw state at high latitudes, enabling new advances in hydrospheric science and applications. Direct measurements of soil moisture and freeze/thaw state are needed to improve understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Soil moisture and freeze/thaw information provided by SMAP will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. Additional SMAP information is available under the Project in Formulation section.

### ***Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI)***

The DESDynI mission is a Tier-1 decadal survey mission that is intended to make global measurements using an L-band Synthetic Aperture Radar (SAR) instrument and a vegetation lidar on two separate spacecraft. The overall DESDynI radar/lidar mission will greatly advance studies and understanding of climate through measurements of ice sheet velocities and quantification of terrestrial vegetation biomass, critically important for closing the global carbon cycle. The mission's interferometric SAR data will be vital to investigation of solid Earth processes and natural hazards such as earthquakes and volcanoes by observing accumulated stresses in the solid Earth. The President's FY 2012 Budget supports continued pre-formulation activities for the DESDynI mission, with the studies focused on defining an appropriate collaboration mission utilizing a NASA radar satellite and a partner-contributed lidar satellite. The mission launch readiness date (LRD) target and initial implementation approach will be determined by the end of FY 2012.

### ***Climate Absolute Radiance and Refractivity Observatory (CLARREO)***

The CLARREO mission, a Tier-1 decadal survey mission, is intended to make precision, stable measurements of the Earth's radiation budget for detection of long-term changes in the climate system and its radiation-related feedback mechanisms during the mission lifetime. The President's FY 2012 Budget provides for an extended Phase A period for the mission definition. During this extended Phase A the mission and science team will work to identify implementation options for obtaining elements of the measurement suite outside of a dedicated series of CLARREO satellites.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

### ***Surface Water and Ocean Topography (SWOT)***

The SWOT mission is a Tier II decadal survey mission that will revolutionize knowledge of the surface water inventory on the continents by precisely measuring of water levels in some three million lakes and water bodies and the discharge of all major rivers. Likewise, SWOT sea surface topography data will illuminate ocean circulation as never before, aiding climate modeling and prediction. SWOT is a partnership mission with CNES, the French space agency. In FY 2012 NASA will complete the pre-formulation activities and enter in Phase A formulation.

### ***Stratospheric Aerosol and Gas Experiment (SAGE III) on the ISS***

The SAGE III instrument is an existing grating spectrometer that measures ultraviolet/visible energy. In 2009, the SAGE-III instrument was removed from storage and successfully passed initial aliveness tests. The President's FY 2012 Budget provides an opportunity to refurbish and recalibrate the instrument for possible flight on the ISS by CY 2014. Observing from the ISS, SAGE III will provide near-global, long-term measurements of key components of the Earth's atmosphere. The most important of these are the vertical distribution of aerosols and ozone from the upper troposphere through the stratosphere. In addition, SAGE III will also provide unique stratospheric and mesospheric temperature measurements of temperature in the stratosphere and mesosphere and profiles of trace gases such as water vapor and nitrogen dioxide that play significant roles in atmospheric radiative and chemical processes. In FY 2012 NASA will complete an ISS accommodation assessment and initial instrument refurbishment.

### ***Active Sensing of CO<sub>2</sub> Emissions over Nights, Days, and Seasons (ASCENDS)***

The ASCENDS mission was recommended by the National Academies' Earth Science decadal survey as the next technological advancement of CO<sub>2</sub> observations from space after the operation of OCO. ASCENDS is designed to sample the total column abundance of CO<sub>2</sub> around the planet with precision and accuracy sufficient to improve our understanding of the sources and sinks of atmospheric CO<sub>2</sub>. ASCENDS is an active system, currently being designed to use the same spectral channels used on OCO-2, using on-board lasers as the light source, and measuring the back reflectance of the laser signals to monitor changes in CO<sub>2</sub>. The measurements from the active ASCENDS instruments will continue and complement the OCO-2 measurements. In FY2012, NASA will continue the pre-Phase A work started in FY 2011 and will define the acquisition and implementation strategy with the completion of the Acquisition Strategy Planning Meeting.

### ***Pre-Aerosol, Clouds, and Ecosystem Mission (PACE)***

The PACE mission will make global ocean color measurements essential for understanding the carbon cycle and how it both affects and is affected by climate change, as well as polarimetry measurements to provide extended data records on clouds and aerosols. Global ocean color measurements will be made by a radiometer instrument while a polarimeter instrument will extend data records on aerosols and clouds using the approach begun by the French PARASOL mission. The President's FY 2012 budget request enables PACE's development for launch by about 2020. The mission will extend key climate data records.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

### ***Gravity Recovery and Climate Experiment - Follow On (GRACE FO)***

The GRACE mission, launched in March 2002, has acquired precision measurements of the Earth's time-varying gravitational field with a precision that led to great discoveries in understanding the Earth system including significant keys to climate change research and future climate adaptation. GRACE FO will continue to map the Earth's gravitational field and its monthly variability by making accurate measurements of the distance between its two satellites, using GPS and a microwave ranging system. It is being designed and developed as a NASA-DLR partnership, following the successful approach used to launch and operate the original GRACE mission. In FY 2011, the GRACE FO mission will complete its Acquisition Strategy Planning Meeting and its pre-Phase A activities. It will complete its KDP-A gate review and enter into formulation in FY 2012, completing the KDP-B transition at the end of FY 2012.

### ***Other Missions and Data Analysis***

Ocean Surface Topography Mission (OSTM) (also known as Jason-2) - OSTM measures sea surface height to an accuracy of less than four centimeters every ten days. The science focus areas served by OSTM include climate variability and change and water and energy cycles. This mission is a follow-on to Jason, and is currently in its prime phase through June 2011.

Terra - Terra collects global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation and with one another. The science focus areas served by Terra include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; Earth's surface and interior; water and energy cycles; and weather. Terra is a joint mission with Japan and Canada.

Aqua - Aqua monitors atmospheric, land, ocean, and ice variables for improved understanding of Earth's water cycle and improved understanding of the intricacies of the climate system. The science focus areas served by Aqua include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; water and energy cycles; and weather. Aqua is a joint mission with Brazil and Japan.

Aura - Aura measures atmospheric chemical composition, tropospheric/stratospheric exchange of energy and chemicals, chemistry-climate interactions, and air quality. The science focus areas served by Aura include: atmospheric composition; climate variability and change; and weather. Aura is a joint mission with the Netherlands, Finland, and the United Kingdom.

TRMM - TRMM measures precipitation, clouds, lightning, and radiation processes over tropical regions. TRMM is one of several spacecraft currently extending the long-term radiation budget record begun in the mid-1980s. The science focus areas served by TRMM include: climate variability and change; water and energy cycles; and weather. TRMM is a joint mission with Japan.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

### ***Other Missions and Data Analysis (continued)***

Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat) - ACRIMSat monitors total solar irradiance. The science focus areas served by ACRIMSat include: climate variability and change; and water and energy cycles. Because ACRIMSAT has continued to operate beyond its original planned base mission, it now provides similar measurements to its operating follow-on mission, the Solar Radiation and Climate Experiment (SORCE).

Quick Scatterometer (QuikSCAT) - QuikSCAT measures global radar backscatter and ocean surface wind speed and direction under nearly all-weather conditions, using the SeaWinds instrument. QuikSCAT is now more than five years beyond its design life, and the rotating antenna has stalled due to normal aging of the lubricant and bearings of the spin mechanism. Even with the antenna stalled, backscatter cross-section data are still being collected for several research investigations in the areas of climate variability and change and weather, although no vector wind measurements are possible. The on-orbit attitude of the QuikSCAT spacecraft has been modified slightly to match the geometry of the QuikSCAT radar backscatter measurements with those of newly launched Indian Space Agency's OSCAT scatterometer instrument, which operates at the same frequency as QuikSCAT; QuikSCAT is thus also serving as the transfer standard to allow the calibration of OSCAT and to provide a consistent, multi-mission climate data record.

Earth Observing-1 (EO-1) - The EO-1 spacecraft collects data to allow paired scene comparisons between the EO-1 Advanced Land Imager (ALI) and the Landsat-7 Enhanced Thematic Mapper Plus (ETM+). The science focus areas served by EO-1 include: carbon cycle, ecosystems, and biogeochemistry; and Earth surface and interior.

Jason-1 - The Jason-1 mission (and OSTM/Jason-2, as well) makes precise measurements of ocean height to support the study of ocean circulation and sea level rise. The science focus areas served by both Jason missions include: climate variability and change; and water and energy cycles. The Jason missions are collaborations between NASA, NOAA, the Centre National d'Études Spatiales (CNES), and (for Jason-2) EUMETSAT.

SORCE - SORCE measures the total and spectral solar irradiance incident at the top of Earth's atmosphere. The science focus areas served by SORCE include atmospheric composition, climate variability and change, and water and energy cycles.

Instrument and mission Science Teams - Instrument science teams help define the scientific requirements for their respective instruments and generate the algorithms used to process the data into useful data products for the investigations. Additionally, the science teams are responsible for validating their own algorithms and data products. ESMP is supported by the Precipitation Science Team, the Ocean Winds Science Team, and the Landsat Science Project Office.

Earth Systematic Missions Senior Review - NASA's Earth Science Division uses senior reviews, which are held every two years, to assess the continued science value of missions in operation. These reviews are comprehensive, evaluating the technical status of the satellites and the value and quality of the data they produce. The senior review helps inform decisions related to extending the missions into the future and the funding level appropriate for each.

Earth Science Program Management - Provides program management support for Earth Science missions, investigations, and activities. Additionally, it provides funding for the ESMP Office and ESSP Program Office, which assist in the overall management and execution of the Earth Science missions.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

Earth Observation Systems (EOS) Research - The EOS research project funds science for the EOS missions, currently Terra, Aqua, Aura, ICESat, and Landsat missions. These individual investigator, competitively selected research projects analyze data from the missions to address related science questions. Some funded projects continue algorithm improvement and validation for the EOS Instruments data products, while overall the selected activities focus on science data analyses and the development of Earth System Data Records (ESDRs), including Climate Data Records (CDRs), relevant to NASA's research program. Studies using ICESat and CryoSat-2 were solicited in the ROSES 2009 sub-element.

Earth Systematic Missions (ESM) Research - The ESM Research project funds science teams for the Earth Systematic missions, currently the NPP and Glory missions. These are individual investigator competitively selected research to analyze data from the missions to address related science questions. In particular, the NPP science investigations are focused on developing climate data records from EOS observations continued by the NPOESS operational observing system.

Ocean Vector Winds Science Team (OVWST) - This project utilizes scientific data received from the QuikSCAT (Quick Scatterometer) satellite which measures ocean surface wind vectors by sensing ripples caused by winds near the ocean's surface. From these data, scientists can compute the winds' speed and direction, acquiring hundreds of times more observations of surface wind velocity each day than can ships and buoys. Previously, this project was associated with the Earth Systematic Mission area wherein the QuikSCAT mission is managed.

Ocean Surface Topography Science Team (OSTST) - This project utilizes scientific data received from the OSTM satellite, which measures global sea surface height. Previously this project was associated with the ESM area wherein the OSTM mission is managed.

Precipitation Science Team - This project utilizes scientific data received from the TRMM satellite to improve the forecasting of weather and severe storm events. Previously this project was associated with the ESM area wherein the TRMM is managed. This science team also supports development of supporting algorithms for the GPM mission.

## Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Complete planned operations of currently operating missions.	Operating missions	No change
Complete the Glory Launch Readiness Review.	Glory	Launch in FY 2011
Launch NPP.	NPP	Launch in FY 2012
Achieve mission success criteria for OSTM.	OSTM	
Successfully complete the SMAP Critical Design Review.	SMAP	
Complete the GPM Pre-Environmental Review.	GPM	
Complete the LDCM Systems Integration Review.	LDCM	

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions

## Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Beg	End
Global Precipitation Measurement Mission (GPM)																	Tech		
																	Form	Jul-02	Nov-09
																	Dev	Dec-09	Jun-13
																	Ops	Jul-13	Jul-16
																	Res		
Glory																	Tech		
																	Form	Oct-03	Nov-05
																	Dev	Nov-05	Feb-11
																	Ops	Feb-11	Feb-14
																	Res		
Landsat Data Continuity Mission (LDCM)																	Tech		
																	Form	Oct-03	Nov-09
																	Dev	Dec-09	Jun-13
																	Ops	Jun-13	Jun-18
																	Res		
SMAP																	Tech		
																	Form	Sep-08	Nov-10
																	Dev	Dec-11	Nov-14
																	Ops	Dec-14	Dec-17
																	Res		
ICESat-2																	Tech		
																	Form	Dec-09	Apr-12
																	Dev	May-12	Oct-15
																	Ops	Jan-16	Jan-19
																	Res		
Ocean Surface Topography Mission (OSTM)																	Tech		
																	Form	Dec-02	Mar-06
																	Dev	Mar-06	Jun-08
																	Ops	Jul-08	Jul-11
																	Res		
NPOESS Preparatory Project (NPP)																	Tech		
																	Form	Mar-00	Nov-03
																	Dev	Dec-03	Oct-11
																	Ops	Oct-11	Jan-16
																	Res		
Terra																	Tech		
																	Form		
																	Dev		
																	Ops	Oct-99	Sep-11
																	Res	Sep-11	
Aqua																	Tech		
																	Form		
																	Dev		
																	Ops	May-02	Sep-11
																	Res	Sep-11	
Aura																	Tech		
																	Form		
																	Dev		
																	Ops	Jul-04	Sep-11
																	Res	Sep-11	
Tropical Rainfall Measuring Mission (TRMM)																	Tech		
																	Form		
																	Dev		
																	Ops	Nov-97	Sep-11
																	Res	Sep-11	
Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat)																	Tech		
																	Form		
																	Dev		
																	Ops	Dec-99	Sep-09
																	Res	Sep-11	
Quick Scatterometer (QuikSCAT)																	Tech		
																	Form		
																	Dev		
																	Ops	Jun-99	Sep-11
																	Res	Sep-11	





<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

## Program Management

GSFC manages NPP, LDCM, Glory, GPM, Terra, Aqua, Aura, TRMM, EO-1, SORCE, ICESat, and ICESat-2. JPL manages OSTM, ACRIMSat, SMAP, QuikSCAT, DESDynI, CLARREO, and Jason.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
GPM	GSFC	GSFC	JAXA - provides the dual frequency precipitation radar and a launch vehicle for GPM.
Glory	GSFC	GSFC	None.
LDCM	GSFC	GSFC	USGS - provides data processing/distribution and on-orbit operations for LDCM.
SMAP	JPL	JPL/GSFC	TBD
ICESat-2	GSFC	GSFC	TBD
DESDynI	JPL	JPL, GSFC	TBD
CLARREO	LaRC	LaRC, GSFC	TBD
OSTM	JPL	JPL	CNES - provides spacecraft, 2 core instruments, and data processing for OSTM. NOAA provides data processing/distribution, ground stations, and on-orbit operations. EUMETSAT provides a ground station and data processing/distribution.
NPP	GSFC	GSFC	NOAA/IPO - provides 3 of 4 instruments and ground system for NPP.
Terra	GSFC	GSFC	Japan's Ministry of Economy, Trade and Industry (METI) provided the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The Canadian Space Agency provided the Measurements of Pollution in The Troposphere (MOPITT) instrument.
Aqua	GSFC	GSFC	The National Space Development Agency (NASDA, now part of the Japan Aerospace Exploration Agency, or JAXA) provided the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) instrument. Brazil's Instituto Nacional de Pesquisas Espaciais (INPE, the Brazilian Institute for Space Research) provided the Humidity Sounder for Brazil (HSB) instrument.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aura	GSFC	GSFC	The National Environmental Research Council of the United Kingdom funded the High Resolution Dynamics Limb Sounder (HIRDLS); the instrument was designed by universities and laboratories in the U.K. and the U.S., including the University of Colorado, Oxford University, the National Center for Atmospheric Research (U.S.), and the Rutherford Appleton Laboratory (U.K.). The University of Edinburgh (U.K.) contributed to data processing algorithms and validation for the Microwave Limb Sounder (MLS). The Ozone Monitoring Instrument (OMI) was built by Dutch Space and TNO TPD in the Netherlands in cooperation with Finnish VTT and Patria Advanced Solutions Ltd. KNMI (Royal Netherlands Meteorological Institute) is the Principal Investigator Institute. Overall responsibility for OMI lies with the Netherlands Agency for Aerospace Programmes (NIVR), with the participation of the Finnish Meteorological Institute (FMI).
TRMM	GSFC	GSFC	The Japan Aerospace Exploration Agency (JAXA) provided the Precipitation Radar (PR) instrument and the launch vehicle (an H-II F6).
ACRIMSat	JPL	JPL	None.
QuikSCAT	JPL	JPL	None.
EO-1	GSFC	GSFC	None.
Jason-1	JPL	JPL	The French Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) is responsible for the Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instrument; THALES built the instrument, and SMP provided the ground beacons. The CNES is also responsible for the Poseidon-2 nadir-viewing radar altimeter; Alcatel Space Industries was prime contractor for the instrument.
ICESat	GSFC	GSFC	None.
SORCE	GSFC	GSFC	None.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions

## Acquisition Strategy

The LDCM instrument was selected through open competition in FY 2007. The Ball Aerospace and Technologies Corporation is building the Operational Land Imaging (OLI) instrument for LDCM. LDCM spacecraft used Rapid Spacecraft Development Office (RSDO) selection, and selected General Dynamics (now Orbital Sciences Corp). The Thermal Infrared Sensor (TIRS) instrument was a directed development, assigned to the GSFC and being built in-house at GSFC.

NPP: Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office. The procurement award for each element was as follows:

- Ball Aerospace: Spacecraft and Ozone Mapping Profile Suite (OMPS) Development;
- NG Electronic Systems: Advanced Technology Microwave Sounder (ATMS) Development;
- ITT Aerospace: Cross-track Infrared Sounder (CrIS) Development;
- Raytheon: Visible/Infrared Imaging Radiometer Suite (VIIRS) Development;
- NG Space Technology: Clouds and the Earth's Radiant Energy System (CERES) Development;
- and
- Raytheon: Ground systems and operations.

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation is building the GPM Microwave Imager (GMI) instrument for GPM. The GPM Core Spacecraft is an in-house development at GSFC. The Dual-frequency Precipitation Radar (DPR) instrument and launch vehicle for the Core Spacecraft will be provided by a foreign partner, JAXA.

The SMAP mission and spacecraft is being developed in house at JPL, with an instrument component developed at by GSFC.

The ICESat-2 mission is being developed with an in-house GSFC instrument, with elements of the instrument to be procured. The spacecraft is expected to be an RSDO procured bus.

Senior Reviews are held every two years to assess the continued science value of missions in operation past their prime mission phase. Preparations are underway for the 2013 Senior Reviews in which all missions then in operation (currently 13) will be evaluated.

The SWOT mission acquisition approach will be defined in FY 2011 and codified in the Acquisition Strategy Meeting completed at the start of FY 2012.

The ASCENDS acquisition approach will be developed in FY 2011 and codified in the Acquisition Strategy Meeting completed by the end of FY 2012.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	4/2011	To determine whether Earth Systematic Missions should enter or continue as an extended mission.	04/2013

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Glory Mission

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>356.4</b>	<b>31.8</b>	<b>-</b>	<b>5.3</b>	<b>3.8</b>	<b>6.1</b>	<b>5.9</b>	<b>6.0</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

*The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## Explanation of Project Changes

In spring 2009, a problem with the Maxwell-supplied spacecraft computer had emerged and NASA changed the baseline Maxwell computer to a BAE Rad750 Single Board Computer, delaying the Glory launch readiness date to November 2010. By May 2010, the BAE unit was delivered and successfully integrated to the Glory Observatory.

The November 2010 LRD was replanned for February 2011 to allow for completion of the Taurus XL launch vehicle's Return to Flight activities, further risk reduction related to spacecraft subsystems, and resolution of launch range manifest conflicts with other scheduled launches. The approved life cycle cost remained the same and costs associated with the LRD change were covered within the project's existing cost reserves.

The mission was also impacted by the repair of a Solar Array Drive Assembly. In August 2010, an inspection revealed excessive wear to its slip ring assembly and it was deemed not flight-worthy. By November 2010, the SADA was repaired, tested, and successfully integrated to the Glory observatory. The November 2010 LRD was changed to February 23, 2011.

The risk associated with the readiness of the Taurus XL launch vehicle was retired following conclusion of the Mishap Investigation Board (MIB) that reviewed the failure of the Taurus XL fairing system, which resulted in the loss of the Orbiting Carbon Observatory. NASA developed a corrective action plan that incorporated the Mishap Investigation Board recommendations. Once all corrective actions had been closed out, NASA's Flight Planning Board approved the Taurus XL for Return to Flight. By this time, however, the LRD was delayed. The new LRD of February 23, 2011, accommodated this delay concurrent with the spacecraft's solar array drive assembly recovery.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Glory Mission

## **Project Purpose**

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The Glory mission will contribute to NASA's research on atmospheric conditions that influence climate and will improve understanding of the natural and human-made factors that contribute to climate change. It will also enable a greater understanding of the seasonal variability of aerosol properties. Both advances are essential components of predicting climate change. Aerosols interact with atmospheric conditions in complex ways that can have large effects on climate.

The mission will also provide precision measurements of the solar irradiance; solar radiation is the dominant, direct energy input into the terrestrial ecosystem, affecting all physical, chemical, and biological processes.

Glory's science objectives are specifically to:

- Determine the global distribution, microphysical properties, and chemical composition of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate; and
- Continue measurement of the total solar irradiance to determine the Sun's direct and indirect effect on Earth's climate.

For more on the scientific questions addressed by Glory, visit <http://glory.gsfc.nasa.gov/>.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Glory Mission

## Project Parameters

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The Glory mission will operate two scientific instruments aboard a modified, preexisting NASA spacecraft. It will fly in NASA's low Earth orbit Afternoon, or A-Train, constellation to enhance the utility of the mission data through synergistic observations from the other satellites. The A-Train constellation currently includes five spacecraft flying in close temporal proximity to each other. The Glory spacecraft will be the sixth satellite in the A-Train when it joins the constellation in FY 2011.

The APS is an advanced polarimeter that will provide measurements to increase our understanding of black carbon soot and other aerosols as causes of climate change. The APS will provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the direct and indirect effects of aerosols on climate. The APS was developed by Raytheon Space and Airborne Systems in El Segundo, CA. As of March 2009, the APS was delivered and successfully integrated to the Glory Observatory.

The TIM instrument provides continuity for the 31-year solar irradiance data record by extending the measurement currently provided by (SORCE. University of Colorado's Laboratory for Atmospheric and Space Physics is developing the TIM sensor, the instrument's Sun pointing platform, and the TIM science operations center.

Orbital Science Corporation in Dulles, VA, is developing the spacecraft and the ground system/mission operations center, and integrated the instruments. Orbital also provides mission systems engineering support and performs mission operations.

Kennedy Space Center is responsible for Glory launch services. The mission will launch on a Taurus XL from Vandenberg Air Force Base, CA.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Glory Mission

## Project Commitments

Glory will launch in February 2011 to begin a three-year prime mission (with a five-year goal) to gather scientific measurements of atmospheric aerosols and solar irradiance.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
APS	Raytheon	Provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols	Same	Same
TIM	U of Colorado LASP	Maintain an uninterrupted solar irradiance data record	Same	Same
Spacecraft	Orbital	Refurbishment of the Vegetation Canopy Lidar (VCL) mission bus	Same	Same
Launch vehicle	Orbital	Taurus XL	Same	Same
Ground System Ops, TIM Science Ops, APS Science Ops	Orbital / Colorado University-Boulder LASP /GSFC Institute for Space Studies	Combination of the commercial ground stations and the networks that connect them	APS: full data processing for 1 yr w/ 2 addtl yrs of archiving. TIM: full data processing for 3 yrs	Same
Mission Ops	Orbital	Operations of the spacecraft and the generation of command uplink	Same	Same
Data Archive	GSFC Earth Science Distributed Active Archive Center (GES DAAC)	Archival and distribution of mission data	Same	Same

## Schedule Commitments

Glory was confirmed for development on December 13, 2005.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
Mission Confirmation Review	12/2005	12/2005	12/2005
Mission Pre-ship review	8/2008	7/2010	12/2010
Launch	12/2008	11/2010	2/2011



**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Glory Mission

## Project Management

Goddard Space Flight Center has project management responsibility. The Science Mission Directorate Program Management Council has program oversight responsibility.

The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
APS	GSFC	GSFC	None
TIM	GSFC	GSFC	None

## Acquisition Strategy

All major procurements for the directed Glory mission were sole-source awarded to meet the objective for an accelerated mission:

Aerosol Polarimetry Sensor: Raytheon Space and Airborne Systems;

Total Irradiance Monitor: University of Colorado Laboratory for Atmospheric and Space Physics; and

Spacecraft/spacecraft support: Orbital Science Corporation.

There are no remaining major procurements, as all instrument and spacecraft contracts are in place.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NASA HQ	N/A	Mission Readiness Review (MRR) - Final pre-flight review of the operational readiness of the mission	02/2011
Performance	NASA HQ	N/A	Launch Readiness Review (LRR) - Final pre-launch review of the launch vehicle readiness	02/2011

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Services Impact of Taurus XL Launch Failure on Glory	If Taurus T-8 (used on OCO mission) launch failure findings and / or corrective actions impact T-9 (Glory) schedule, then the Glory LRD will be impacted.	In October 2010, NASA's Flight Planning Board approved the closure of the KSC/Launch Services program's Return to Flight activities. At this point, the Return to Flight activities had impacted the November 22, 2010 launch readiness date by two months. The new LRD of February 22, 2011, accommodated this delay concurrent with the spacecraft's SADA recovery.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>631.2</b>	<b>82.1</b>	<b>-</b>	<b>13.6</b>	<b>6.4</b>	<b>6.3</b>	<b>6.0</b>	<b>5.5</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

*The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## Explanation of Project Changes

The changes to the NPP budget are due to the launch delay from September 2011 until October 2011 caused by late delivery to NASA of the VIIRS instrument and CrIS by the NPOESS Integrated Program Office.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	NPOESS Preparatory Project (NPP)

## **Project Purpose**

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NPP is a joint mission with NOAA and the U.S. Air Force to extend key environmental measurements for weather prediction and research. The satellite will measure atmospheric and sea surface temperatures, humidity profiles, land and ocean biological productivity, cloud and aerosol properties, and earth radiation budget quantities.

The NPP mission has two objectives: Provide a continuation of select global change observations following the Earth Observing System missions Terra and Aqua; and provide the Nation's operational meteorological satellite system with risk-reduction demonstration and validation for critical sensors, algorithms, and ground processing. Due to NPOESS program delays propagated to the successor Joint Polar Satellite System (JPSS; see "Project Management") program, NPP data will be used operationally to avoid gaps in operational weather data.

For more information, please visit: <http://jointmission.gsfc.nasa.gov>.

## **Project Parameters**

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The NPP spacecraft is based on a modified Ball Commercial Platform 2000 bus with a five-year design life. The NPP orbit is a polar, Sun-synchronous orbit at a nominal altitude of 824 kilometers. Four of the instruments are newly developed sensors based on heritage NASA sensors. The ATMS has been developed by NASA, and three of the instruments (VIIRS, CrIS, and OMPS) were developed by the NPOESS Integrated Program Office (IPO). A fifth sensor, CERES was a spare sensor developed by NASA for the EOS Program.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

## Project Commitments

NPP is being managed for a target launch in October 2011 and will undertake the following scientific measurements over its five-year operating life: atmospheric and sea surface temperatures, humidity soundings, land and ocean biological productivity, cloud and aerosol properties, and Earth radiation budget measurements. NASA's commitment is for an LRD of February 2012 including an additional \$35 million mission development costs. The commitment launch readiness date, lifecycle cost, and development cost reflect residual uncertainty with the NPP partner-provided instruments and the ground system development. The commitment LRD considers as well the effects of the crowded launch manifest in late 2011, should an LRD slip be required. Funds will not be reprogrammed unless the actual launch date slips beyond the internal date.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
VIIRS	Raytheon SBRS	Provide global imagery in visible and infrared frequency bands: 0.3 to 14 microns / 400 m resolution.	Same	Same
OMPS	Ball Aerospace	Collection of total column and vertical profile ozone data with 300-380 nm / LIMB 290-1000 nm .	Same	Same
CrIS	ITT Aerospace	Temperature and moisture profiles at 3.9-15.4 microns.	Same	Same
ATMS	NG Electronic Systems	Temperature and moisture profiles at 22 channels / 23-183 ghz.	Same	Same
CERES	NG Space Technology	Provide Earth radiation budget measurements in shortwave (0.3-5micron) and longwave (8-12 micron) bands	Same	Same
Spacecraft	Ball Aerospace	5-year design life, mass is 2228 kg, Power 1400 watts.	Same	Same
Launch vehicle	Boeing	Delta II 7920.	Same	Same
Ground system	Raytheon	Command, Control, and Communication Segment (C3S) and Interface Data Processing Segment (IDPS).	Same	Same

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

## Schedule Commitments

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
CrIS Flight Model Delivery	Oct 2005	June 2010	Same
ATMS Flight Model Delivery	Apr 2005	Oct 2005	Same
OMPS Flight Model Delivery	Sep 2005	Aug 2008	Same
VIIRS Flight Model Delivery	Nov 2005	Dec 2009	Same
CERES Flight Model Delivery	N/A	Oct 2008	Same
Operations Readiness Review	Jun 2006	Apr 2011	Same
Launch	Oct 2006	Sep 2011	Oct 2011

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

## Project Management

GSFC is responsible for NPP project management. Agency PMC has program oversight responsibility. NOAA/DOD IPO is responsible for managing development of OMPS, CrIS, and VIIRS instruments. Responsible official is the Earth Science Division Director.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	None	None
ATMS Development	GSFC	None	None
OMPS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CrIS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
VIIRS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CERES Refurbishment	GSFC	LaRC	NOAA
Data archive and storage	GSFC	None	NOAA
Ground Systems and Ops	NPOESS-IPO	None	NOAA

## Acquisition Strategy

Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office.

The procurement award for each element was as follows:

- Ball Aerospace: Spacecraft and OMPS Development;
- NG Electronic Systems: ATMS Development;
- ITT Aerospace: CrIS Development;
- Raytheon: VIIRS Development;
- NG Space Technology: CERES; and
- Raytheon: Ground systems and operations.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NPP IRT	N/A	Operations Readiness Review	4/2011

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Command, Control, and Communication Segment (C3S) Ground System Development Delay	If the C3S is not ready to support satellite testing, a launch delay may result.	Coordinate closely with partner (NOAA) to ensure all necessary resources are applied to complete C3S development in parallel with satellite testing.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Global Precipitation Measurement (GPM)

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>349.2</b>	<b>155.0</b>	<b>-</b>	<b>83.8</b>	<b>68.7</b>	<b>41.4</b>	<b>27.2</b>	<b>20.1</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

*The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## Explanation of Project Changes

The changes to the project's budget reflect the deletion of a second GPM Microwave Imager (GMI-2), which would have been available to fly on a future Low-Inclination Observatory (LIO).

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Global Precipitation Measurement (GPM)

## **Project Purpose**

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The GPM mission will advance the measurement of global precipitation, making possible high spatial resolution precipitation measurements available at a three-hour or less refresh rate over much of the globe. A joint mission with JAXA, GPM will provide the first opportunity to calibrate measurements of global precipitation (including the distribution, amount, rate, and associated heat released) across tropic, mid-latitude, and polar regions.

The GPM mission has the following scientific objectives:

- Advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques. These advanced measurements will be used to calibrate dedicated and operational passive microwave sensors, with the goal of achieving global sampling;
- Advance understanding of global water/energy cycle variability and fresh water availability. Improved measurements of the space-time variability of global precipitation will substantially close the water/energy budget and elucidate the interactions between precipitation and other climate parameters;
- Improve climate prediction by providing the foundation for better understanding of surface water fluxes, soil moisture storage, cloud/precipitation microphysics and latent heat release in Earth's atmosphere;
- Advance Numerical Weather Prediction (NWP) skills through more accurate and frequent measurements of instantaneous rain rates with better error characterizations, and the development of improved assimilation methods; and
- Improve flood-hazard and fresh-water-resource prediction capabilities through better temporal sampling and wider spatial coverage of high-resolution precipitation measurements, and innovative designs in hydro-meteorological modeling.

For more information see <http://gpm.gsfc.nasa.gov/>.



<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Global Precipitation Measurement (GPM)

## Project Parameters

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The GPM project includes a Core Observatory Spacecraft and a robust set of spare GMI instrument subsystems to ensure the GMI instrument, NASA's instrument contribution to the Core Observatory, is ready on schedule. The Core Observatory will leverage passive microwave measurements from other operating and planned "satellites of opportunity" by calibrating their measurements to its own. The resulting sampling rate over different areas of the globe will depend on the number and orbits of the satellites of opportunity, but given the prevalence of passive microwave instruments on operational satellite systems, the global sampling will be robust.

The NASA Core Observatory will fly in a 65 degree inclined orbit at an altitude of 407 kilometers; the 65 degree orbit provides improved latitude coverage over TRMM (whose orbit was inclined 35 degrees). The Core Observatory's two scientific instruments will provide active and passive microwave measurements of precipitation.

The JAXA-supplied Dual-frequency Precipitation Radar (DPR) instrument has cross-track swath widths of 245 and 120 kilometers, in Ku-band and Ka-band, providing three-dimensional observation of rain and an accurate estimation of rainfall rate. The KuPR (13.6 GHz) subsystem of the DPR is an updated version of the highly successful radar flown on TRMM.

The GMI instrument is a conically-scanning radiometer that will provide significantly improved spatial resolution compared to the TRMM Microwave Imager (TMI).

The Core Observatory Spacecraft will be launched from Tanegashima Space Center, Japan, on an H-IIA launch vehicle. The DPR and GMI data will be relayed using the TDRSS multiple access and single access service.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Global Precipitation Measurement (GPM)

## Project Commitments

The GPM Core Observatory is planned for a launch in July 2013 to begin a three-year prime mission (five-year goal). When calibrated with existing and planned passive microwave measurements from other satellites, GPM will provide global measurements of precipitation with a sampling frequency of three hours or less over much of the globe.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Core Observatory	GSFC	Provides platform for the GMI and JAXA-supplied DPR instruments.	Same	Same
Low-Inclination Observatory	N/A	N/A	Changed to be partner-provided	Second GMI instrument deleted
Dual-frequency Precipitation Radar (DPR)	JAXA	Provides cross-track swath widths of 245 and 120 kilometers, for the Ku precipitation radar (KuPR) and Ka-band precipitation radar (KaPR).	Same	Same
GMI	GSFC	Provides 13 microwave channels ranging in frequency from 10 GHz to 183 GHz; four high frequency, millimeter-wave, channels about 166 GHz and 183 GHz. 1.2 meter diameter antenna.	Same	Same
Launch Vehicle	JAXA	H-IIA	Same	Same

## Schedule Commitments

GPM entered formulation in July 2002. The below milestone dates reflect the December 2009 KDP-C commitments.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
KDP-C	Dec 2009	Dec 2009	Dec 2009
Core Observatory LRD	Jul 2013	Jul 2013	Jul 2013

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Global Precipitation Measurement (GPM)

## Project Management

GSFC has project management responsibility. The Agency Program Management Council has program oversight responsibility.

The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Core Observatory	GSFC	GSFC	None
Core Observatory: GMI	GSFC	GSFC	None
Core Observatory: DPR	GSFC	GSFC	JAXA
Launch vehicle and services: Core Observatory	GSFC	None	JAXA
Ground Systems	GSFC	GSFC	None

## Acquisition Strategy

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation (BATC) will build the GMI instrument for GPM. The GPM core spacecraft will be an in-house development at GSFC. The DPR instrument and launch vehicle for the Core Observatory will be provided by a foreign partner (JAXA).

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	12/2009	System Integration Review (SIR)	5/2011

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Non-NASA Constellation elements	Expanded global sampling depends on data from "spacecraft of opportunity" that are not part of this project.	NASA is developing data algorithms that allow GPM to make the broadest possible use of microwave instruments on other spacecraft; NASA participates in interagency and international planning processes for operational Earth observation measurements to maximize the leverage opportunities for GPM.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Landsat Data Continuity Mission (LDCM)

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>434.5</b>	<b>106.0</b>	<b>-</b>	<b>152.0</b>	<b>64.1</b>	<b>1.5</b>	<b>1.5</b>	<b>1.6</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

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*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

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## Explanation of Project Changes

The LDCM project, which was approved to proceed with development in December 2009, now has a fully integrated budget including the development and accommodation of TIRS.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Landsat Data Continuity Mission (LDCM)

## Project Purpose

Unprecedented changes in land cover and use are having profound consequences for weather and climate change, ecosystem function and services, carbon cycling and sequestration, resource management, the national and global economy, human health, and society. The Landsat data series, begun in 1972, is the longest continuous record of changes in Earth's surface as seen from space and the only satellite system designed and operated to repeatedly observe the global land surface at moderate resolution. Landsat data are available at an affordable cost, providing a unique resource for people who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research.

The purpose of LDCM is to extend the record of multi-spectral, moderate resolution Landsat-quality data, and to meet U.S. Government operational and scientific requirements for observing land use and land change.

For additional information, visit the LDCM mission Home Page: <http://ldcm.nasa.gov/>.

## Project Parameters

LDCM is being developed for an LRD that will minimize a potential data gap in the archive due to the fuel-limited life of Landsat-7. Recent analyses by the USGS and NASA have estimated the Landsat-7 mission should continue to operate through at least the end of 2012. The LDCM mission completed its Confirmation Review on November 30, 2009, and its KDP-C transition review on December 16, 2009. Due to the high national importance of the mission and the need to maintain the continuity of the Landsat data record, NASA and USGS will implement the LDCM mission for a December 2012 launch, providing necessary budget and other resources to ensure all mission elements are ready for this launch date. A probabilistic analysis has determined that the launch date could move as far as June 2013, driven by the late addition of the TIRS instrument. However, the LDCM project has been directed to execute all necessary contracts and actions to accomplish the December 2012 Launch Readiness Date.

LDCM consists of a two science instruments (the Operational Land Imager and the Thermal Infrared Sensor), a spacecraft, and a mission operations element. The LDCM is in implementation and system level requirements are baselined to provide the following system-level performance parameters:

- Earth Spatial-Temporal Coverage: 16-day repeat coverage of the global land mass;
- Spatial Resolution: 30 meters (visible, NIR, SWIR), 120 meters (thermal); 15 meters (panchromatic);
- Radiometric Performance: accuracy, dynamic range, and precision sufficient to detect land cover change using historic Landsat data;
- Data: 185-kilometer cross track-by-180-kilometer along track multi-spectral image of Earth's surface; and
- Mission Life: five years.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Development:** Landsat Data Continuity Mission (LDCM)

## Project Commitments

After launch, the spacecraft and OLI instrument will operate for a minimum of five years. The TIRS instrument will operate for a minimum of three years.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
OLI	Ball Aerospace and Technology Corporation	Provide Landsat-equivalent data to extend the Landsat data of Earth's land surface for five years.	Same	Same
TIRS	GSFC	Provide Landsat-equivalent thermal data to extend the Landsat data of Earth's land surface for three years.	New	Same
Spacecraft	General Dynamics	Provide performance and reliability commensurate with OLI and TIRS data requirements.	Same	Same
Launch Vehicle	ULA	Provide launch service access to space.	Same	Same
Mission Operations Element	Hammers Corporation	Provide capability for command and control, mission scheduling, long-term trending and analysis, and flight dynamics analysis.	Same	Same

## Schedule Commitments

LDCM completed its spacecraft CDR and mission CDR in FY 2010. Due to the high national importance of the mission and the need to maintain continuity of the Landsat data record, NASA and USGS will strive to launch LDCM in December 2012. The LDCM project has been directed to execute all necessary contracts and actions to accomplish the December 2012 launch. Consistent with NASA policies regarding commitments to cost and schedule, the LDCM launch shall be no later than June 2013.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
Formulation			
Award OLI contract	July 2007	July 2007	July 2007
Confirmation Review	Dec 2009	Dec 2009	Dec 2009
Critical Design Review (CDR)	Apr 2010	Apr 2010	Apr 2010
PSR	Sep 2012	Sep 2012	Sep 2012
Launch	Jun 2013	Jun 2013	Jun 2013
Handover of Operations to USGS	Sep 2013	Sep 2013	Sep 2013

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Development:</b>	Landsat Data Continuity Mission (LDCM)

## Project Management

LDCM is under the Earth Systematic Missions program within the Earth Science Division (ESD) of SMD. The NASA Associate Administrator (AA) is the decision authority; the ESD Director is the responsible official; and GSFC is the lead management organization.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Operational Land Imager	GSFC	GSFC	None
Thermal Infrared Sensor	GSFC	GSFC	None
Spacecraft	GSFC	GSFC	None
Ground System	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey
Mission Operations	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey

## Acquisition Strategy

NASA's acquisition plan includes acquiring separate elements of the LDCM mission through open competition, with GSFC acting as the mission integrator and leading the element source selections. NASA has issued competitively selected contracts for the following major elements: Ball Aerospace and Technology Corporation for the development of the Operational Land Imager in July 2007; General Dynamics Corporation for the development of the spacecraft in April 2008; and Hammers Corporation for the development of the Mission Operations Element (MOE) in September 2008. The Thermal Infrared Sensor will be designed and built in-house at GSFC utilizing civil servants and support contractor personnel.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	9/2008	Systems Requirement Review - Successful	N/A
Performance	HQ and GSFC	7/2009	Mission Preliminary Design Review - Successful	N/A
Performance	HQ and GSFC	5/2010	Mission Critical Design Review	N/A
Performance	HQ and GSFC	N/A	Systems Integration Review	08/2011

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Thermal Infrared Sensor (TIRS) development risk	The TIRS instrument has an aggressive development schedule due to late addition to the instrument complement and there is a risk that TIRS will not be delivered on schedule to meet the LDCM launch readiness date.	The LDCM project will develop alternative observatory integration and test scenarios to allow for late arrival of TIRS. In the event that TIRS cannot be delivered in time to meet the LDCM launch date, a flyable mass model will be developed.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Ice, Cloud, and land Elevation Satellite-2

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>38.9</b>	<b>-</b>	<b>102.1</b>	<b>159.4</b>	<b>128.8</b>	<b>83.1</b>	<b>28.6</b>

*Note:*

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## Project Purpose

ICESat-2 will continue the measurements begun with the ICESat mission, measuring elements of ice-sheet mass balance, sea ice freeboard and large-scale biomass to quantify polar ice sheet contributions to current and recent sea level change and linkages to the climate state. In addition ICESat-2 will quantify regional ice sheet changes to assess mechanisms driving that change and improve predictive ice sheet models. The science focus areas served by ICESat-2 include climate variability and change, Earth surface and interior, and water and energy cycles. The ICESat-2 mission is one of four first-tier missions recommended by the National Academies' decadal survey, titled "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond." The ICESat-2 mission will draw lessons learned from the original ICESat satellite launched in FY 2003 and operated through CY 2009.

For more information see <http://nasascience.nasa.gov/missions/icesat-ii>.

## Project Preliminary Parameters

The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation lidar. It will be launched into a 450 kilometer, 94-degree, 91-day repeat orbit.

Pursuant to Senate Report 111-34, incorporated by reference into the Statement Accompanying the Consolidated Appropriations Act, 2010 (PL 111-117) and as required by NASA standard project formulation processes, the ICESat-2 project is working toward a mature [Technology Readiness Level - 6] baseline instrument concept in preparation for formal mission confirmation at the end of FY 2012. This includes the photon-counting approach to provide cross-track measurement capabilities identified in Senate Report 111-34. As part of this engineering process, the project will use an airborne instrument to simulate the space-based measurements to optimize the final instrument design and to develop algorithms to meet all Level 1 requirements. Based on cost and schedule analysis of the ICESat-2 preliminary design, a baseline budget and launch readiness date will be established at mission confirmation.



<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Systematic Missions
<b>Project In Formulation:</b>	Ice, Cloud, and land Elevation Satellite-2

### Estimated Project Deliverables

ICESat-2 is in formulation and does not yet have an official launch date; however, the Phase A target launch date is January 2016 with a notional three-year prime mission.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Spacecraft	TBD	Competitively selected	Same	Same
Lidar Instrument	TBD	Multi-beam micro-pulse laser with photon-counting detector	New	Same
Launch Vehicle	TBD	Competitively selected	Same	Same

### Estimated Project Schedule

ICESat-2 is in formulation. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2011 PB Request	FY 2012 PB Request
<i>Formulation</i>			
Formulation			
KDP-A	N/A	September 2009	December 2009
Launch readiness date (LRD)	N/A	Late 2014/Early 2015	January 2016

### Project Management

GSFC has project management responsibility. The Science Mission Directorate Program Management Council has programmatic oversight. The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	TBD	TBD
Lidar	GSFC	GSFC	None
Mission Operations	GSFC	TBD	TBD
Launch Vehicle	GSFC	TBD	TBD

### Acquisition Strategy

The ICESat-2 lidar instrument will be designed and tested at GSFC using component procurements from industry. The spacecraft vendor will be competitively selected. The approach for the mission operations element has not yet been determined. The source and selection method for launch services will be determined during formulation.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Ice, Cloud, and land Elevation Satellite-2

### Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	ICESat-2 Independent Review Team	02/2009	Mission Concept Review/Requires Delta Review	11/2009
Performance	ICESat-2 Independent Review Team	11/2009	Mission Concept Review /Successfully completed	
Performance	Standing Review Board	N/A	System Requirements Review (SRR) and Mission Definition Review (MDR)	03/2011

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Soil Moisture Active and Passive (SMAP)

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>70.0</b>	<b>-</b>	<b>135.2</b>	<b>172.3</b>	<b>31.1</b>	<b>29.6</b>	<b>14.5</b>

*Note:*

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## Project Purpose

The SMAP mission will provide unique information on global soil moisture and its freeze/thaw states to enable advances in hydrospheric science/applications and climate research. It is one of the four Tier-1 NASA missions recommended by the Earth science and applications decadal survey. Direct measurements of soil moisture and freeze/thaw states are needed to improve understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Obtaining global soil moisture measurements every three days, SMAP's data will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. SMAP mission data will contribute to the goals of four Earth Science focus areas (carbon cycle, ecosystem, weather, and climate). SMAP is based on the soil moisture and freeze/thaw mission concept developed under the ESS) Program Hydrosphere State (Hydros) project and builds on the Hydros formulation and technology risk mitigation studies conducted in 2003 through 2005.

For more information see <http://nasascience.nasa.gov/missions/smap>.

## Project Preliminary Parameters

The SMAP observatory employs a dedicated spacecraft and will be launched into a near-polar, sun-synchronous orbit on an expendable launch vehicle. The baseline SMAP instrument suite includes a radiometer and a synthetic aperture radar operating in the L-band range (1.20-1.41 GHz) designed to make coincident measurements of soil emission and backscatter to sense the top five centimeters of soil through moderate vegetation cover. These measurements will be analyzed to yield estimates of soil moisture and freeze/thaw state. Data will be acquired for a period of three years and a comprehensive validation program will be used to assess random errors and regional biases in the soil moisture and freeze/thaw estimates.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Soil Moisture Active and Passive (SMAP)

### Estimated Project Deliverables

SMAP is planned for a launch in November 2014 for a three-year prime mission. SMAP will make soil moisture measurements around the entire Earth every three days.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Spacecraft	JPL	Provides platform for the instrument	Same	Same
L-Band SAR	JPL	Combined with Radiometer provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	Same	Same
L-Band Radiometer	GSFC	Combined with SAR provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	Same	Same
Launch Vehicle	TBD	TBD	Same	Same

### Estimated Project Schedule

Milestone Name	Formulation Agreement Estimate	FY 2011 PB Request	FY 2012 PB Request
<i>Formulation</i>			
Formulation			
KDP-C	April 2010	December 2010	Mid-to-Late 2011
Launch readiness date (LRD)	Mid CY 2015		November 2014

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Soil Moisture Active and Passive (SMAP)

## Project Management

JPL has project management responsibility for SMAP. The Science Mission Directorate Program Management Council has program oversight responsibility.

The Earth Sciences Division Director is the responsible official.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	JPL	None
L-Band SAR	JPL	JPL	None
L-Band Radiometer	JPL	GSFC	None
Launch Vehicle	JPL	To be determined	To be determined

## Acquisition Strategy

The SMAP spacecraft will be built in-house at JPL. The SMAP instrument, combining the SAR and radiometer, will be integrated by JPL. The SAR will be built by JPL and the radiometer by GSFC. The deployable antenna/boom and instrument spin assemblies will be procured through open competition. The source and selection method for launch services will be determined later in formulation.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SMAP Standing Review Board (SRB)	05/2009	Mission Design Review-successfully completed.	Mid 2011

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth System Science Pathfinder

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b><u>128.4</u></b>	<b>-</b>	<b><u>187.8</u></b>	<b><u>180.6</u></b>	<b><u>229.5</u></b>	<b><u>238.4</u></b>	<b><u>214.3</u></b>
Aquarius	22.3	-	4.9	4.6	4.9	5.1	5.2
OCO-2	62.0	-	91.0	41.0	13.0	4.0	0.0
Venture Class Missions	6.3	-	61.5	103.9	179.7	196.6	175.7
Other Missions and Data Analysis	37.9	-	30.5	31.1	31.9	32.7	33.4

**Note:**

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

## Program Overview

ESSP includes a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, PI-led missions. These missions complement the larger and more broadly capable missions in ESMP. ESSP missions have focused scientific objectives to support a selected subset of studies of the atmosphere, oceans, land surface, polar ice regions, or solid Earth. Investigations include development and operation of remote-sensing instruments and the conduct of investigations using data from these instruments. In FY 2012, NASA will continue the accelerated development of an Orbiting Carbon Observatory reflight mission (OCO-2) with the objective to launch in February 2013. With the successful OCO-2 progress, NASA will begin the initial design phase of the OCO-3 instrument mission of opportunity, culminating in a KDP-B gate review transition for OCO-3 by the end of FY 2012. In FY 2012, NASA will continue the five airborne science investigations selected through the initial Venture Class solicitation (EV-1) in FY 2010 and started in FY 2011. ESSP will complete the evaluation and selection of winning proposals from two additional Earth Venture AO calls. The second Earth Venture AO call, EV-2, for small complete satellite missions will be released in FY 2011, and the initial annual call (EV-Instrument) for instruments of opportunity in support of the Climate Initiative will be released early in FY 2012. The winning proposals for each call will be selected during FY 2012. The target small mission launch date will be no more than five years after selection, and the anticipated instrument delivery as early as FY 2016 or FY 2017 (depending on the complexity of the instrument selected). Annual EV-Instrument calls are an integral part of the Climate Initiative and are supported in the President's Budget. The ESSP currently has two missions in development, OCO-2 and Aquarius; three operating missions, GRACE, CloudSat, and CALIPSO; and five EV-1 airborne science investigations underway.

For more information see <http://earth.nasa.gov>.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth System Science Pathfinder

## **Plans For FY 2012**

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The ESSP Program plans for FY 2012 include:

- On orbit checkout and calibration/validation of the Aquarius/SAC-D mission;
- Completion of the OCO-2 Phase C and the KDP-D transition of this mission into Acceptance, Test, and Launch Operations (ATLO) activities;
- Completion of the initial design phase of the OCO-3 instrument mission of opportunity, culminating in a KDP-B phase transition by the end of FY 2012;
- Initial science data acquisitions from the selected EV-1 investigations;
- Evaluation and selection of the winning proposal from the EV-2 small-mission AO;
- Evaluation and selection of the winning proposal(s) from the first annual EV-Instrument AO, soliciting significant Earth-observing instruments for flights of opportunity; and
- Continued operations of the GRACE, CloudSat, and CALIPSO missions based on the direction of the 2011 Senior Review.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth System Science Pathfinder

## Project Descriptions and Explanation of Changes

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### ***Aquarius***

Aquarius will observe and model seasonal and year-to-year variations of sea-surface salinity and how these variations relate to changes in the water cycle and ocean circulation. The science focus areas served by Aquarius will include: climate variability and change; and water and energy cycles. Aquarius is currently in Phase D with a manifested launch date of June 2011 and three years of prime mission life. Additional detail can be found in the Aquarius development section of this document.

### ***Orbiting Carbon Observatory - 2***

OCO-2 is a replacement for the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's implementation approach to the greatest degree practical to reduce mission development risk. The OCO-2 mission objectives are identical to those for OCO. OCO-2 employs a dedicated spacecraft with a single instrument, designed to measure CO<sub>2</sub> and O<sub>2</sub> near-infrared absorptions from reflected sunlight. Additional detail can be found in the OCO-2 section of this document.

### ***Venture Class Missions***

"Venture-class" Earth System Science Pathfinder missions have been established in response to the National Academies' Earth science decadal survey. Venture-class missions will be small, competed science investigations, and will include suborbital payloads; instruments to be flown as missions of opportunity on host spacecraft (e.g., non-NASA spacecraft or ISS); and small, focused satellites.

### ***Other Missions and Data Analysis***

Included in this line item are three operating spacecraft:

- GRACE, launched in FY 2002, measures Earth's gravity field and its variations with time;
- CloudSat, launched in FY 2006, measures cloud characteristics to increase understanding of the role of optically thick clouds in Earth's radiation budget; and
- The CALIPSO mission, launched in FY 2006, measures the vertical distribution of clouds and aerosols in the atmosphere.

In addition, this line includes the ESSP research project providing funds for the science teams for the ESSP missions. The science teams are comprised of competitively selected individual investigators who analyze data from the missions to address the related science questions.

### ***Orbiting Carbon Observatory-3 Instrument***

OCO-3 is an instrument to be built from the spare parts residual from the OCO-2 instrument and mission development. The instrument will be modified from the OCO-2 design to allow it to be compatible with multiple possible payloads. The OCO-3 instrument capabilities will be consistent with those of the OCO-2 instrument and mission.



**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder

## Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Complete Senior Reviews (SRs) to make recommendations on mission extensions.	GRACE, CloudSat, and CALIPSO	
Complete the Orbiting Carbon Observatory-2 (OCO-2) Systems Integration Review.	OCO-2	
Complete the ICESat-2 Preliminary Design Review.	ICESat-2	
Complete the Earth Venture 1 (EV-1) Investigation Readiness Reviews (IRR) and begin initial field campaigns.	Earth System Science Pathfinder	

## Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		Beg	End
Aquarius																	Tech		
																	Form	Oct-03	Sep-05
																	Dev	Oct-05	Jun-11
																	Ops	Jun-11	Jul-14
																	Res		
Orbiting Carbon Observatory - 2																	Tech		
																	Form	Feb-10	Sep-10
																	Dev	Oct-10	Jan-13
																	Ops	Feb-13	Feb-15
																	Res		
Gravity Recovery and Climate Experiment (GRACE)																	Tech		
																	Form		
																	Dev		
																	Ops	Mar-02	Sep-11
																	Res		
CloudSat																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-06	Sep-11
																	Res		
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (CALIPSO)																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-06	Sep-11
																	Res		
<div> <div></div> Tech &amp; Adv Concepts (Tech)  <div></div> Formulation (Form)  <div></div> Development (Dev)  <div></div> Operations (Ops)  <div></div> Research (Res)  <div></div> Represents a period of no activity for the Project </div>																			

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth System Science Pathfinder

## Program Management

The Agency Program Management Council has program oversight responsibility. The Earth Science Division Director is responsible for program oversight.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aquarius	JPL	JPL	Argentina's Comision Nacional De Actividades Espaciales (CONAE), National Oceanic and Atmospheric Administration, Naval Research Laboratory, National Center for Atmospheric Research.
Orbiting Carbon Observatory - 2	JPL	JPL	N/A
GRACE	Earth Science Division	JPL	Deutsches Zentrum fur Luft- und Raumfahrt (DLR, the German Aerospace Center); Office National d'Etudes et de Recherches Aerospatiale (ONERA) of France; GeoForschungsZentrum (German National Research Centre for Geosciences); National Oceanic and Atmospheric Administration; National Geospatial-Intelligence Agency.
CloudSat	Earth Science Division	JPL	Canadian Space Agency; U.S. Air Force; Department of Energy.
CALIPSO	Earth Science Division	LaRC	France's Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) and Alcatel; SODERN; Institut Pierre Simon Laplace, France.

## Acquisition Strategy

ESSP Program missions are selected competitively via AO. The AO process uses peer review for the science content of the proposed missions, as well as thorough independent review of their technical, management, and cost elements. Evaluations and selections will be completed for the second Venture Class call, EV-2, and for the first instrument only AO, EV-I1. OCO-2 is a NASA-directed mission, but remains under the ESSP Program, as the original OCO was selected under an AO. NASA will seek to duplicate the OCO acquisition strategy to the greatest degree practical.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	05/2009	CALIPSO, GRACE, and CloudSat were reviewed as part of the Earth Science biennial Senior Review process. All three missions were approved for extended operations through the end of FY 2011.	04/2011
Performance	SRB	09/2010	OCO-2 will be subject to a KDP-C Confirmation Review to establish the mission development baseline.	02/2012

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Aquarius

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>221.5</b>	<b>22.3</b>	<b>-</b>	<b>4.9</b>	<b>4.6</b>	<b>4.9</b>	<b>5.1</b>	<b>5.2</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

*The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## Explanation of Project Changes

The FY 2011 budget for Aquarius reflected the cost for a launch no earlier than December 2010. Spacecraft development delays at NASA's foreign partner, Argentina's National Committee of Space Activities (CONAE) spacecraft have set the launch to no earlier than June 2011.

## Project Purpose

The Aquarius mission will investigate the links between the global water cycle, ocean circulation, and climate. It will observe and model variations of sea surface salinity, and how these relate to changes in the water cycle and ocean circulation. This will yield an unprecedented view of the oceans' role in climate and weather. For more information visit: <http://aquarius.gsfc.nasa.gov/>.

## Project Parameters

Aquarius is an instrument on Argentina's CONAE spacecraft, Satellite de Aplicaciones Cientificas-D (SAC-D). The combined NASA and CONAE instruments and spacecraft form the Aquarius/SAC-D observatory. This observatory will be launched into a polar, Sun-synchronous orbit that allows global coverage of ice-free ocean surfaces consistent with Aquarius/SAC-D science observational targets. The Aquarius instrument includes an L-band microwave radiometer (1.413 GHz) and scatterometer (1.26 GHz). The radiometer will measure the surface brightness temperature, which is related to the surface emissivity and physical temperature of the seawater. The surface emissivity is determined by the dielectric constant of seawater, which is related to salinity. The scatterometer is required to provide coincident information of sea surface roughness, a critical correction term for retrieval of sea surface salinity.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Aquarius

## Project Commitments

Aquarius is manifested to launch no earlier than June 2011 to begin a three-year prime mission to measure sea surface salinity with the precision, resolution, and coverage needed to characterize salinity variations and investigate the linkage between ocean circulation, Earth's water cycle, and climate variability.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Aquarius Instrument (integrated radiometer/scatterometer)	JPL	L-band microwave radiometer at 1.413 GHz; scatterometer at 1.26 GHz; SSS measurements with root-mean-sq random errors and systematic biases $\leq 0.2$ psu on 150 km sq scales over ice-free oceans.	Same	Same
Spacecraft	CONAE	SAC-D	Same	Same
Launch Vehicle	Boeing	Delta II	Same	Same
Data Management	GSFC	N/A	Same	Same
Operations	CONAE	Command and telemetry	Same	Same

## Schedule Commitments

The Aquarius mission entered a Risk Mitigation Phase (RMP) in July 2002. Following the RMP, the project was authorized to proceed to a formulation phase in December 2003. The Aquarius mission was authorized by the NASA Science Mission Directorate to proceed to development on October 12, 2005. In November 2007, the NASA Science Mission Directorate Program Management Council approved a replan of Aquarius, including a launch delay to May 2010. In December 2009, the NASA Science Mission Directorate Program Management Council approved another replan of Aquarius, including a launch delay manifesting the Aquarius/SAC-D mission for a January 2011 launch. In September 2010, NASA, in coordination with CONAE, made the decision to delay the launch readiness date to June 2011 based on the progress on SAC-D testing and assessment of the remaining schedule. The replan of the Aquarius project for this change is scheduled to take place in March 2011.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
Mission Confirmation Review	September 2005	September 2005	September 2005
Mission CDR	August 2007	July 2008	July 2008
Aquarius Instrument Pre-ship Review [FY 2008 APG]	May 2008	May 2009	May 2009
Launch	March 2009	January 2011	June 2011

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Aquarius

## Project Management

The Jet Propulsion Laboratory is responsible for project management. The Science Mission Directorate Program Management Council is responsible for program oversight. The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Launch Vehicle	KSC	KSC	None
Ground System	JPL	GSFC	None
Aquarius Instrument	JPL	JPL	None
Spacecraft	CONAE	None	CONAE
Radiometer	JPL	GSFC	None
Data management	GSFC	GSFC/JPL	None
Mission operations	CONAE	None	CONAE

## Acquisition Strategy

Aquarius was competitively selected from proposals submitted in response to ESSP AO 3. All elements of the project were included in that selection, and there are no other planned major procurements.

The launch vehicle procurement was awarded to Boeing. GSFC and JPL were selected for the remaining project elements not provided by CONAE.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Aquarius Standing Review Board	7/2010	Aquarius Replan Review -- Determined readiness of Aquarius instrument integration with the SAC-D Observatory (Phase D). Recommendation to proceed to Phase D.	3/2011

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Spacecraft Development Delays	Further delays could impact launch date.	Monitor Comision Nacional De Actividades Espaciales (CONAE) progress and confirm commitments; reassess available schedule reserves.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Orbiting Carbon Observatory-2 (OCO-2)

## FY 2012 Budget Request

Budget Authority (\$ millions)	Prior	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>29.1</b>	<b>62.0</b>	<b>-</b>	<b>91.0</b>	<b>41.0</b>	<b>13.0</b>	<b>4.0</b>	<b>0.0</b>

*Note: For the FY 2012 Budget Request, project life cycle estimates, required to meet the requirements of section 103 of the NASA Authorization Act of 2005 (P.L. 109-155; 42 U.S.C. 16613), have been consolidated in the Management and Performance Section of this document. This consolidation provides for a comparative analysis across projects, and the inclusion of corrective action plans for the projects that have exceeded their original baseline estimates by greater than fifteen percent.*

*The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth System Science Pathfinder
<b>Project In Development:</b>	Orbiting Carbon Observatory-2 (OCO-2)

### Project Purpose

Data received from OCO-2 will support climate research by enabling an improved understanding of natural, distributed CO<sub>2</sub> sources and sinks and ocean/atmosphere and land/atmosphere CO<sub>2</sub> exchange processes. OCO-2 measurements will initiate a global time series of atmospheric CO<sub>2</sub> for direct support of policy development and verification of regulations and environmental treaties. Rapid development and launch of OCO-2 is a key element of the President's Budget.

OCO-2 replaces the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's detailed design and implementation approach to the greatest possible degree to reduce risk. The mission objectives of OCO and OCO-2 are identical.

### Project Parameters

The OCO-2 mission consists of a dedicated spacecraft with a single instrument, flying in a near-polar, Sun-synchronous orbit launched by an expendable launch vehicle. The orbit's early afternoon equator crossing time maximizes the available signal and minimizes diurnal biases in CO<sub>2</sub> measurements associated with photosynthesis. The OCO-2 flight system uses hardware components, software, and processes with space flight heritage, in particular drawing from the spacecraft and mission design implemented for the OCO mission. The spacecraft structure is made of honeycomb panels that form a hexagonal shape. This structure houses the instrument and the spacecraft bus components. Panels with solar cells are attached and stowed such that the whole structure fits inside the small fairing of the Taurus XL launch vehicle. For the OCO-2 mission, the spacecraft has been elongated to accommodate the instrument, and the instrument has been embedded into the structure of the spacecraft, exactly as was done for the OCO spacecraft. The instrument consists of a single telescope feeding three high-resolution grating spectrometers. The optics will be cooled to approximately 270 Kelvin (K) and the Focal Plane Arrays (FPAs) to approximately 120 K. The instrument will measure CO<sub>2</sub> and O<sub>2</sub> near-infrared absorptions from reflected sunlight. Remote sensing retrieval algorithms will process these data to yield estimates of the column-averaged CO<sub>2</sub> dry air mole fraction, XCO<sub>2</sub>. The total weight of the observatory is about 530 kilograms. The original OCO successfully completed qualification of this configuration prior to launch.

### Project Commitments

The OCO-2 is planned to launch in February 2013 to begin a two-year mission. OCO-2 will provide atmospheric CO<sub>2</sub> measurements with near global coverage of the sunlit portion of Earth on a 16-day repeat cycle.

Project Element	Provider	Description	FY 2011 PB Request	FY 2012 PB Request
Spacecraft	Orbital Sciences Corp	Provides platform for the instrument	New	Same
OCO-2 Instrument	JPL	Three channel, high-resolution grating spectrometer measuring CO <sub>2</sub> and O <sub>2</sub> near-infrared absorptions from reflected sunlight	New	Same
Launch Vehicle	Orbital Sciences Corp	Taurus XL	New	Same

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Orbiting Carbon Observatory-2 (OCO-2)

## Schedule Commitments

Based on design maturity due to the heritage of OCO, OCO-2 entered Formulation in February 2010. Completion of KDP-C and transition to Development occurred in September 2010.

Milestone Name	Confirmation Baseline	FY 2011 PB Request	FY 2012 PB Request
<i>Development</i>			
KDP-C	N/A	December 2010	September 2010
LRD	N/A	February 2013	February 2013

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## Project Management

JPL has project management responsibility for OCO-2. The Science Mission Directorate Program Management Council has program oversight responsibility. The Earth Sciences Division Director is the responsible official.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	None	None
Instrument	JPL	JPL	None
Ground System	JPL	JPL	None
Launch Vehicle	JPL	KSC	None

## Acquisition Strategy

The OCO-2 spacecraft will be built by Orbital Sciences Corporation. A sole source procurement is being pursued to maintain the same configuration as OCO. The OCO-2 instrument will be built in-house at JPL.

## Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	OCO-2 SRB	09/2010	OCO-2 will complete a KDP-C Confirmation Review, to establish the mission development baseline.	02/2012



**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Orbiting Carbon Observatory-2 (OCO-2)

## Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Vehicle Failure	If Taurus XL launch vehicle failure occurs, then there will be a loss of mission.	NASA is employing a rigorous Return-to-Flight program on the Taurus XL launch vehicle for the Glory mission. The OCO team is being provided insight into these results.
Single String Component Failure	If an OCO-2 single string (i.e. no redundancy) component fails, then there may be a loss of mission.	OCO-2 (based on the competed OCO design) was designed to have some single string components. Thorough analyses and testing is being performed to mitigate this risk as much as possible.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Multi-Mission Operations

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b><u>149.0</u></b>	<b>=</b>	<b><u>159.9</u></b>	<b><u>158.8</u></b>	<b><u>159.4</u></b>	<b><u>162.9</u></b>	<b><u>166.6</u></b>
Earth Science Multi-Mission Operations	149.0	-	159.9	158.8	159.4	162.9	166.6

*Note:*

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Multi-Mission Operations

## Program Overview

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The Earth Science Multi-Mission Operations program acquires, preserves, and distributes observational data to support Earth Science focus areas in conformance with national science objectives. The Earth Science focus areas are: climate variability and change; atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; weather; and Earth surface and interior. Facilities involved in this undertaking include data handling, data processing, and archiving systems.

NASA's principal Earth Science information system is EOSDIS, which has been operational since August 1994. EOSDIS acquires, processes, archives, and distributes Earth science data and information products created from satellite data, which arrive at the rate of more than four trillion bytes (four terabytes) per day. Having successfully created this system, NASA is using advances in information technology to expand its capabilities while providing continuous service to the user community. The successful completion of the Evolution of EOSDIS Elements (EEE) effort has increased efficiency and operability and increased data usability by the research, application, and modeling communities. EOSDIS provides services and tools to enable use of NASA's Earth science data in next-decadal models, research results, and decision support system benchmarking and improved support for end users. The budget request for FY 2012 incorporates cost savings that result from this effort and supports upcoming missions including GLORY, OCO-2, and GPM. EOSDIS project management is working with decadal survey mission teams to understand their mission data characteristics and guide further improvements and system evolution. A system plan for 2015 and beyond will take into account evolution needs for new missions being developed in response to the National Academies' decadal survey. Small investments will enable the system to keep technologically current, and incorporate new research data and services.

NASA Earth science information is archived at eight Distributed Active Archive Centers (DAACs) located across the United States. The DAACs specialize by topic area, and make their data available to researchers around the world. For more information, please see <http://eos.nasa.gov/eosdis>.

Research opportunities related to EOSDIS are available through ACCESS at <http://access-projects.gsfc.nasa.gov/>.

MEaSURES is available at <http://measures-projects.gsfc.nasa.gov/>. Participants in these programs are solicited through the ROSES opportunities.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Multi-Mission Operations

## Plans For FY 2012

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The Earth Science Multi-Mission Operations program will continue operation of EOSDIS, the DAACs and their accompanying functions, and Core System Science Data Processing Systems. The maintenance of these systems is important to collection of data from Earth Science satellites in orbit, as well as the continuity of Earth science research efforts.

NASA plans to continue supporting the EEE effort to enable a service-oriented architecture between now and 2015. EOSDIS personnel will continue working with decadal survey mission team data and mission operations representatives.

Five-year MEaSURES projects began work in FY 2008 to continue development of multi-instrument Earth System Data Records, including Climate Data Records. An ACCESS solicitation will be released in NASA's ROSES-2011 and selections for new ACCESS Projects are planned in FY 2012. Projects from the third program solicitation, Earth System Data Records Uncertainty, will be in their second year. These projects, performed under Cooperative Agreements are proving very valuable for maintaining active involvement of the research and modeling communities involved with the EOSDIS architecture and informing core infrastructure evolution decisions.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Multi-Mission Operations

## Project Descriptions and Explanation of Changes

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### ***EOSDIS***

EOSDIS is the central data handling system for NASA's Earth science efforts. EOSDIS components funded in the project include:

- Production of EOS standard science data products, using algorithms and software developed by EOS investigators;
- Active archive of all NASA Earth science data, as well as ordering, distribution, and data management, ensuring also the preservation of data, products, related algorithms, and system-configuration history;
- Information management, enabling researchers to rapidly locate and retrieve data critical to their work; and
- User support for research scientists, educators, students, and users in public agencies responsible for operational applications of the data, as well as for the general public.

The Precipitation Processing System (PPS) is a measurement-based data and information system at GSFC that evolved from the TRMM Science Data and Information System (TSDIS). PPS continues to support the TRMM Science Team with analyzed rainfall data from TRMM as well as data from other precipitation instruments, and is also developing further to support the upcoming GPM mission to be launched in FY 2013. PPS, beginning with the core software architecture of TSDIS, is being generalized from a system coded for a single mission to one capable of processing data from multiple satellites. The level 1 algorithm code from TRMM is being extended and enhanced to work with GPM Microwave Imager. Tasks, such as unique GPM packet de-segmentation and multiple precipitation instruments near-real-time, are being added. To support long-term precipitation needs; extendibility, flexibility, and portability are being added to the base architecture.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Multi-Mission Operations

### ***Earth Science Multi-Mission Operations***

This project funds the Elements of EOSDIS Evolution, aimed at improving the efficiency and effectiveness of EOSDIS while reducing the cost, and the Distributed Active Archive Centers, which collect, disseminate, and archive Earth science data at eight centers across the Nation:

- The Alaska SAR Facility, which collects Synthetic Aperture Radar data, and information on sea ice, polar processes, and geophysics;
- The GSFC Earth Sciences Data and Information Services Center, which collects information on atmospheric composition, atmospheric dynamics, global precipitation, ocean biology, ocean dynamics, and solar irradiance;
- The Langley Research Center DAAC, which collects data on Earth's radiation budget, clouds, aerosols, and tropospheric chemistry;
- The Land Processes DAAC, which collects land processes data;
- The National Snow and Ice Data Center, which collects snow and ice data, as well as information about the cryosphere and climate;
- The Oak Ridge National Laboratory DAAC, which collects data on biogeochemical dynamics and ecological data for studying environmental processes;
- The Physical Oceanography DAAC, which collects information on oceanic processes and air-sea interactions; and
- The Socioeconomic Data and Applications Center, covering population, sustainability, multilateral environmental agreements, natural hazards, and poverty.

### **Program Commitments**

<b>Commitment/Output FY 2012</b>	<b>Program/Project</b>	<b>Changes from FY 2011 PB Request</b>
Provide services and tools for use of NASA's Earth Science data in next-decadal models, research results, and decision support system benchmarking.	EOSDIS and DAACs	None
Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users.	Earth Science Efficiency Measure	None
Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index.	Earth Science Efficiency Measure	None

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Multi-Mission Operations

## Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Beg	End	
EOSDIS and Multi-Mission Operations (including DAACs)																			
Elements of EOSDIS Evolution (phased start-up beginning in FY 2008)																			
<div> <div></div> Tech &amp; Adv Concepts (Tech)  <div></div> Formulation (Form)  <div></div> Development (Dev)  <div></div> Operations (Ops)  <div></div> Research (Res)  <div></div> Represents a period of no activity for the Project </div>																			

## Program Management

The Science Mission Directorate and the Program Management Council have oversight responsibility for this program. The Earth Science Data and Information System Project Office at GSFC has primary responsibility for the program.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
PPS	GSFC	GSFC	NASA operates and is further developing the PPS to provide analyzed data from the TRMM and GPM missions. Both TRMM and GPM are joint missions of NASA and JAXA, a key stakeholder.
ACCESS, MEaSUREs, Earth System Data Records Uncertainty Analysis (peer-reviewed data research)	SMD	NASA Headquarters	None.
Multi-Mission Operations (operations and maintenance of Core EOSDIS systems; DAACs, Evolution of EOSDIS)	GSFC	Earth Science Data and Information Systems Office, Goddard Space Flight Center	Key participants in the Multi-Mission Operations project include the space agencies of Europe, Canada, Germany, France, and Japan. Other U.S. agency partners include the National Oceanic and Atmospheric Administration (Department of Commerce), U.S. Geological Survey (Department of the Interior), and the Department of Defense.

## Acquisition Strategy

The EOSDIS Core System is a high-performance software system that provides science data ingest, archive and distribution capabilities for a multitude of Earth science instruments. Maintenance and operations for this system, utilized by three DAAC's post-Step 1 EEE, is performed under contract procured by GSFC.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Multi-Mission Operations

### Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	Earth Science Subcommittee	10/2009	The Earth Science Subcommittee reported that they were impressed by the success and clear sense of direction of this program.	TBD
Quality	DAAC Data Priority Workshops	ongoing	DAAC archive holdings peer reviewed for scientific merit. Multiple reviews related to individual research areas, all successful; several recommendations in work.	annual



**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Technology

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>45.6</b>	<b>-</b>	<b>46.1</b>	<b>47.9</b>	<b>51.9</b>	<b>53.6</b>	<b>54.2</b>
Earth Science Technology	45.6	-	46.1	47.9	51.9	53.6	54.2

*Note: The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.*

*In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.*

*In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.*

## Program Overview

Advanced technology plays a major role in enabling Earth research and applications programs by advancing our technical capabilities for improving understanding of the total Earth system and its effects of natural and human-induced changes on the global environment. The Earth Science Technology Program (ESTP) supports the Earth Science Division by enabling previously unforeseen and infeasible science investigations, enhancing existing measurement capabilities, and reducing the cost, risk, and development times of Earth science measurements. The Earth Science Technology Office (ESTO) coordinates with the new Agency-wide technology program through the Science Mission Directorate's Assistant Director for Innovation and Technology; this person is a member of the NASA Technology Executive Council hosted by the Office of the Chief Technologist.

ESTO manages ESTP to provide strategic, science-driven technology assessments and requirements development. The office implements a science-focused technology program by pursuing promising scientific and engineering concepts through open competition solicitations.

For more information, please see: <http://esto.nasa.gov>.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Technology

## **Plans For FY 2012**

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ESTP will plan and develop new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements, and data system capabilities. Planning will start with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess measurement options for meeting technology performance requirements. Implementation will be performed by selecting and funding tasks from competed solicitations in the three project areas: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives. Ongoing activities in these areas are described in more detail in the project description section of this document.

For FY 2012, ongoing investigations will be managed in the Instrument Incubator, Advanced Information Systems Technology, and Advanced Component Technology program elements. These investigations resulted from FY 2010 and 2011 ROSES solicitations. Both solicitations supported the expanded and accelerated mission set enabled by the President's Budget including the Climate Initiative.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Technology

## **Project Descriptions and Explanation of Changes**

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### ***Instrument Incubator***

This element develops new and innovative instruments and measurement techniques at the system level, including laboratory development and airborne validation.

A solicitation for new instrument technologies was released in FY 2010 and resulted in 16 new awards for sensors measuring atmospheric trace gases, aerosols, clouds, gravity fields, ocean topography, tropospheric winds, thermal land imaging, Earth radiation balance, precipitation, ocean color, snow, and vegetation. Instrument technologies include imagers, spectrometers, lidars, microwave sounders, and radars. These projects began in FY 2011 and will continue through FY 2014.

Among the 35 projects already ongoing in FY 2010, notable Instrument Incubator projects included the development of an instrument for highly accurate measurements of carbon dioxide, which will benefit future decadal survey missions. Another project made significant progress for measurements in a broad spectral range from ultraviolet to visible to infrared. The program also supported the development of a unique type of lidar that could one day be used to make three-dimensional wind measurements.

### ***Advanced Information Systems Technology***

This element develops end-to-end information technologies that enable new Earth-observation measurements and information products. The technologies are used to process, archive, access, visualize, communicate, and understand science data. The next solicitation is part of ROSES-11, with selections expected in the first quarter of FY 2012.

The earlier solicitation released in June 2008 awarded 20 projects that began in early FY 2009, focused on three areas needed to support future Earth science measurements: Sensor System Support (to incorporate autonomy and rapid response in the sensing process and improve the science value of data); Advanced Data Processing (to improve or enhance the information extracted from the data stream); and Data Services Management (to better manage the growing body of Earth science data and allow for efficient exchange).

For example, one project team developed techniques for validating space-borne soil moisture measurements that will be used by a future decadal survey mission. The Real-Time Mission Monitor, a science decision support tool that uses cutting-edge information technology, was deployed in the GRIP field campaign. Also in support of a future mission, a project team is streamlining data acquisition to reduce downlink data volume through the use of on-board processing.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Earth Science Technology

### ***Advanced Technology Initiatives***

The Advanced Technology Initiatives element provides for the development of critical component and subsystem technologies for instruments and platforms, mostly in support of the Earth science decadal survey. The most recent solicitation for advanced component technologies occurred under ROSES-10 and focused on such areas as space-qualified laser transmitters, passive optical technologies, and microwave and calibration technologies.

During FY 2010 there were 16 active projects. One notable investment was development of a new approach for mirror telescope arrays. An unconventional type of material was introduced that substantially reduced the cost and turnaround time for the development of the mirror. This technology will likely prove useful for a number of planned flight missions that make use of lidars. Another successful project was development of a radiometer receiver module that will enable efficient space-borne ocean altimeters. Other awards support measurements of solar radiance, ozone, aerosols, and atmospheric gas columns for air quality and ocean color for coastal ecosystem health and climate emissions.

### **Program Commitments**

<b>Commitment/Output FY 2012</b>	<b>Program/Project</b>	<b>Changes from FY 2011 PB Request</b>
Annually advance a portion of funded technology developments by one technology readiness level.	ESTP	None
Annually mature several technologies to the point of readiness for demonstration.	ESTP	None
Annually enable or improve one new science measurement capability.	ESTP	None

### **Program Management**

The Earth Science Division within the Science Mission Directorate has oversight responsibility of the technology program office.

<b>Project</b>	<b>Management Responsibility</b>	<b>NASA Center Performers</b>	<b>Cost-Sharing Partners</b>
Instrument Incubator	ESTO	GSFC, JPL, LaRC, ARC, GRC, JSC	None.
Advanced Info Systems	ESTO	GSFC, JPL, LaRC, ARC, GRC, MSFC	None.
Advanced Tech Initiatives	ESTO	GSFC, JPL, LaRC	None.

### **Acquisition Strategy**

Tasks are procured primarily through full and open competition, such as the annual ROSES announcements.

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Earth Science Technology

### Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC - Earth Science Sub Committee	10/2009	The Earth Science Subcommittee reviewed the Earth Science Technology program for infusion of new technologies and participation of universities in developing the new generation of technologists. The committee was overall pleased with the technology program; it wanted to ensure that tasks focus on being able to reduce cost in missions and are directed towards enabling/enhancing specific measurements.	10/2012

**Mission Directorate:** Science  
**Theme:** Earth Science  
**Program:** Applied Sciences

## FY 2012 Budget Request

Budget Authority (\$ millions)	FY 2010	Ann CR. FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
<b>FY 2012 President's Budget Request</b>	<b>35.3</b>	<b>-</b>	<b>33.1</b>	<b>34.3</b>	<b>35.5</b>	<b>36.7</b>	<b>36.9</b>
Pathways	35.3	-	33.1	34.3	35.5	36.7	36.9

*Note:*

The FY 2011 appropriation for NASA was not enacted at the time that the FY 2012 Request was prepared; therefore, NASA is operating under a Continuing Resolution (P.L. 111-242, as amended). Amounts in the "Ann. CR FY 2011" column reflect the annualized level provided by the Continuing Resolution.

In accordance with the President's proposal to implement a five-year non-security discretionary spending freeze, budget figures shown for years after FY 2012 are notional and do not represent policy. Funding decisions will be made on a year-by-year basis.

In FY 2012 through FY 2016, civil service labor and expenses (CSLE) funds are administered within a single consolidated account in each of the appropriations, and not allocated within the project amounts shown above. The allocation to each project is reflected in the summary budget table included in the beginning of this budget request, which provides a full cost view. In FY 2010 and FY 2011, amounts are presented in full cost.

## Program Overview

The NASA Applied Sciences Program leverages NASA Earth Science satellite measurements and new scientific knowledge to enable innovative and practical uses by public and private sector organizations. The Applied Sciences program supports applied research and applications projects to enable near-term uses of Earth science knowledge, discover and demonstrate new applications, and facilitate adoption of applications by non-NASA stakeholder organizations. Applied research and applications projects are designed to improve decision-making activities to help the Nation better manage its resources, improve quality of life, and strengthen the economy. NASA develops Earth science applications in collaboration with end-users in public, private, and academic organizations. Examples include improved public health tracking systems for infectious diseases with the Centers for Disease Control; advances in accuracy of volcanic ash advisories for airplane pilots with the National Weather Service and the Federal Aviation Administration; improved wildfire smoke predictions with the U.S. Forest Service to reduce downwind public exposure; advances in assessing impacts of climate change on U.S. National Park ecosystems and improving land management strategies; improved assessment of flooding and landslide conditions with International Red Cross to plan mitigation and response activities; development of drought indicators with National Drought Mitigation Center to support end users' conservation and agriculture decisions; and international disaster management support with the U.S. Agency for International Development (USAID). The program's primary outcomes are the routine, sustained uses of NASA Earth science products in user organizations' policy, business, and management decisions to serve society; the impacts are the resulting socioeconomic benefits from the improved decisions. The program enables operational users to imagine and anticipate possible applications from upcoming satellite missions and to provide input to mission development teams to increase the societal benefits of NASA missions.

For more information, please see: <http://AppliedSciences.nasa.gov>.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Applied Sciences

## **Plans For FY 2012**

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In FY 2012, the Applied Sciences Program will continue or initiate projects across a range of application themes, including health and air quality, water resources, disasters, and ecological forecasting. These projects are competitively selected each year through NASA's ROSES solicitations. In FY 2012, the program will feature joint solicitations with research and end-user organizations, contributions to mission science teams to ensure consideration and incorporation of applications requirements throughout the mission design process, and continuation of efforts to build skills and capabilities for accessing and applying Earth observations data to benefit society. The FY 2012 President's Budget enables the program to initiate new solicitations, strengthen end-user involvement in early-phase mission planning, improve the communication of results, and support products and services provided by the NASA/USAID jointly funded SERVIR network.

<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Applied Sciences

## Project Descriptions and Explanation of Changes

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### ***Applied Sciences***

In FY 2012, the Applied Sciences Program will sponsor several solicitations and competitively-selected projects across the range of applications themes described above, including topics that cut across these themes:

- Decision Support projects: These are three- to four-year projects that are carried out collaboratively with end user organizations to integrate Earth observations data into their decision-making activities and enable the organizations' sustained use of the Earth observations data.
- Applications Feasibility projects: These are short-term, proof-of-concept projects to generate and test preliminary ideas for applications of Earth science products to determine their potential value and readiness for a more in-depth project.
- Applied Sciences Teams: These are multiple-year efforts by teams of applications specialists and scientists to address key applications-oriented challenges and develop critical data products needed by the applied community and end users.

The program supports joint solicitations with the Earth Science Research Program and supports some applications-oriented projects that are identified in solicitations managed by the research program's science focus areas, especially science mission teams. The projects also include a small number of activities that cut across and support such tasks, including capacity building projects, workshops, and outreach activities.

In FY 2012, the Applied Sciences Program will continue the expanded SERVIR network and enhance both its scientific capabilities across a broader set of NASA Earth science products and its service as a test bed for innovative applications.

### ***Performance Evaluation***

In FY 2012, the Applied Sciences Program will use an Applications Readiness Level metric to assess the performance of the program's aggregate activities. The Applications Readiness Level is a nine-point scale that articulates the expected maturation of an application along a continuum from basic research to use in an operational setting. The program will begin to use this metric to assess the difficulty of individual stages as a way to identify critical success factors for applications projects.



<b>Mission Directorate:</b>	Science
<b>Theme:</b>	Earth Science
<b>Program:</b>	Applied Sciences

### Program Commitments

Commitment/Output FY 2012	Program/Project	Changes from FY 2011 PB Request
Issue competed peer reviewed research awards.	Applied Sciences	None
Maximize resource utilization through streamlining processes and operations across the program.	Applied Sciences	None
Conduct impact evaluation on mature projects.	Applied Sciences	None
Advance at least 25 percent of decision-support projects at least one Applications Readiness Level.	Applied Sciences	None

### Program Management

Applied Sciences program responsibility resides within the Earth Science Division of the Science Mission Directorate.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Earth Science Applications	NASA HQ	GSFC, LaRC, SSC, JPL, MSFC, and ARC	EPA, NOAA, USDA, FAA, DOE, DOI, CDC, USAID ; state agencies, and regional organizations such as the Western Governors Association, American Water Resources Association, Gulf of Mexico Alliance. Private sector and universities. Non-Profit and intergovernmental organizations, such as United Nations Food and Agriculture Organization.

### Acquisition Strategy

The Earth Science Applications program is based on full and open competition. Grants are peer reviewed and selected based on NASA Research Announcements and other related announcements. The program emphasizes cost-sharing in projects, especially decision support projects.

### Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Academies	10/2007	The Applied Sciences program strategy and implementation.	2013
Relevance	Applied Sciences Analysis Group	11/2010	Applied Sciences program strategy and implementation.	11/2011